POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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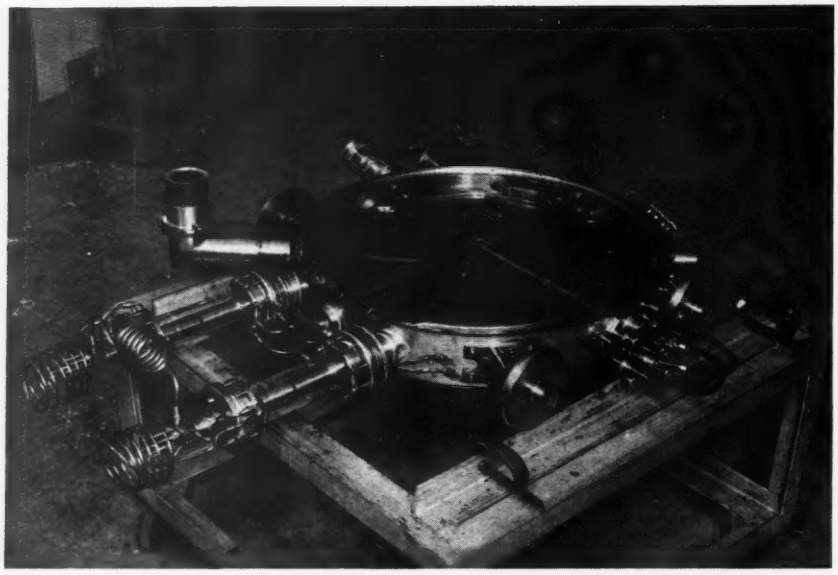


Cyclotron in course of construction at the University of Michigan

Electron Whirligig

WHIRLIGIG is perhaps not the most dignified name to apply to anything quite so profound in its working or so delicate in its construction as the fantastic apparatus pictured above and yet to the layman this term describes it as well as any other. It *is* a whirligig, even though a rather strange one. Its real name is "Cyclotron" but that, you may be willing to concede, if anything, is even less descriptive to the initiated.

Its function, we can assure you, is quite as fantastic as its appearance or its name, for it is a device used to smash atoms. In it, electrons and other particles are whirled around and around at inconceivable speeds until finally they emerge with energy enough to smash their way squarely into the heart of atoms. Starting at the center with low velocity, electrons are driven around this disk in a spiral path under the combined influence of powerful magnetic and electrostatic fields, gaining speed at each revolution. Finally, as they reach the edge of the disk they are shunted into a chamber where they impinge with full velocity upon samples of whatever material is being investigated and as they do so, they actually smash the atoms of which the material is composed, often "transmuting" it into an entirely different substance. Already many of the 92 elements have been disintegrated by the Cyclotron. Platinum has been changed into gold, lithium into helium. The quantities involved are extremely small but if it can be done on a small scale, who is there rash enough to imply that it will not be done on a larger scale in the future?

Actually the "Cyclotron" is a power plant for producing the most concentrated quantities of energy in the world. With this particular unit, which is that being constructed by Professor Cork and his associates at the University of Michigan, and using the nucleus of the atom of "heavy" hydrogen as the whirling particle, a potential of 14,000,000 electron-volts will be attained. Remember that an electron under the influence of only a single volt will accelerate to a speed of 368 miles per second.

It would be easy, in fact one is inclined to build up fantastic notions regarding the possibilities of this type of equipment—fanciful pictures of transmuting lead into gold or of unlimited sources of atomic power and as long as we do not take them too seriously there is no harm in indulging in such mental gymnastics. Perhaps the time will come when all we will need is a cyclotron for the solution of all our power problems but until that time arrives, keep your boilers and turbines and oil engines and water wheels in condition. The cyclotron is still only a whirligig for our scientists but it seems to be keeping them amused. A rotating copper disk between the poles of a magnet once amused Michael Faraday; as a consequence, today, we have motors and generators and an electrical industry. Somehow, it seems to pay to have scientists amuse themselves.

PERSONALITIES in the news section—W. W. Dalmage, chief engineer of Henry Ford's power plants and A. R. Smith, chief engineer of General Electric both had a lot to do with the largest and highest temperature industrial turbine—Morris E. Leeds, president of Leeds & Northrup was awarded the Henry Lawrence Gantt Gold Medal and the honorary degree of Doctor of Engineering in the same week—Eddie Schwanhausser, manager of Worthingtons Buffalo works is president of the Buffalo Chamber of Commerce.

WITH THE EDITORS

Power Interchange

FOR THE PAST DECADE at least, power interchange between utility and industrial plants has been an active and controversial subject, albeit an economic skeleton seldom mentioned publicly. There is no question of its economic advantage, nor does the engineering involved offer unsurmountable difficulties, the real stumbling block to progress has been the policy of the utility companies, a whole-hog-or-none attitude feebly backed up by questionable objections of the operating departments which do not want additional responsibility on already burdened backs.

There are indications that utility executives have, under the stress of the depression and keener competition from more efficient industrial plants, softened considerably and are willing to discuss coöperation. This change of heart has in many cases been too late to save important industrial jobs, but it does indicate definite hope for the future.

Power interchange is perhaps an unfortunate expression which is too narrow for present day needs. As a start in the proper direction we might well assume that no industrial plant is economically justified in making more electric power than can be generated as a byproduct of the steam which it uses. Some companies have closely approached that ideal, others hope to.

Today industrial power engineers are as well, if not better, trained than utility engineers for many of them are ex-utility men broadened by the wider industrial requirements. They can build and operate plants just as cheaply and when company policy allows the two sides to sit down and settle the problem to their mutual advantage, the ultimate in coöperation will soon be achieved. Due to growing industrial power requirements, actual interchange demands will probably decline in importance but possibilities of closer coöperation are broadened considerably by the increasing importance of the sale of high pressure steam.

Atmospheric Comfort by Code

DRY AND BROWN as are the fields and prairies of the middle west and much of the hill country of the south, blistering hot and buckling as are the pavements in the cities and through the country, glaring bright and uncomfortable to look at as are the street walls of city buildings, and worst of all inescapable as is the heat that pours into the bodies of people compelled by force of circumstances to work, live and sleep (if possible) in the sweltering atmosphere that accompanies a temperature of 100 deg. or more—can anybody be surprised that the public seeks the air conditioned theaters, restaurants, trains, homes and buildings?

Economic conditions have had much to do with the dilatory manner in which air conditioning equipment has been installed and there is danger today that the air conditioning industry will suffer because of the numerous, inadequate systems that are being installed, particularly in homes. Many so-called systems have little of practical value to recommend them and are almost sure to be a disappointment to the owner as seasons pass. Such a condition should by all means be averted if possible. Manufacturers of air conditioning equipment, engineers and architects will do a notable service to the public, as well as to themselves, if they will inform customers and prospective customers on the fundamentals of air conditioning so that they will not be unadvisedly lead into purchasing and installing equipment inadequate for their purposes.

What the public does not seem to realize is that air conditioning is a science and an art, almost as complicated as that of water treatment. It is a science in that it requires careful design of equipment to handle the proper amounts of air, water and steam to assure correct temperatures and distribution. It is an art in that to obtain maximum comfort to the occupants of an air conditioned space requires skillful manipulation of several elements of the system in accordance with varying atmospheric conditions, class of work and physical condition of the occupants.

A commendable step in the right direction is the action taken by the Air Conditioning Manufacturers' Association to formulate a code of engineering standards for air conditioning to which it is hoped the industry will conform in its designs and operation. This code now in tentative form is published on another page of this issue and its provisions are well worth consideration by all engineers in charge of air conditioning equipment.

The Salesman

PERIODICALLY some engineer, makes for himself, the discovery that salesmen carry a varied bag of tricks and that whether they be classified as "pests" or "helps" depends largely upon himself. Naturally the salesman's first duty is to present his products and keep them before the engineer. He asks and has a right to expect, only common business courtesy. In performing his duties, however, he picks up a fund of information on new products, new methods and news. He cannot be expected to peddle gossip and trade secrets, but he is anxious to make his visits truly helpful to the engineer if given a little coöperation. How about trying to find out how useful some of them can be? That is, the good ones will succeed—the bad ones will soon pass from the picture.

NEW STEEL magnets containing from 15 to 20 per cent aluminum have been developed by a Japanese, Mr. Michima. They are being produced by the Czechoslovakian firm Waffenfabrik Ing. F. Janeceh. The power of these magnets is superior to that of the Tungsten and Cobalt ones formerly in use, as a round magnet of approximately 12 cm. in diameter will support about 100 lb. of iron, which indicates considerable improvement.

New 35,000 Kw. "Top" Unit

New Addition to Well-known Cincinnati Generating Station Consists of 35,000 Kw. Superposed Turbo-generator and Three Pulverized Coal Fired Boilers, Operating at 1200 Lbs. Pressure and at 900 Deg. F.

By D. S. BROWN
Manager, Electric Production Dept.
The Union Gas and Electric Co.

IN 1916, THE PEAK load of the Cincinnati System was 36,000 kw. and this was supplied by the Plum Street Station, located on the Miami and Erie Canal at Plum and Charles Streets. Due to the World War, the expansion of industrial activity in Cincinnati at this time caused a very rapid increase in the demand for electric power and in this year the construction of West End Power Station at Front and Rose Streets was begun.

The first section of this station consisted of the present building and two 25,000 kw. turbo-generators, supplied by eight boilers at 260 lb. and 600 deg. F.

*From a paper presented before the Cincinnati Section of the A.S.M.E.

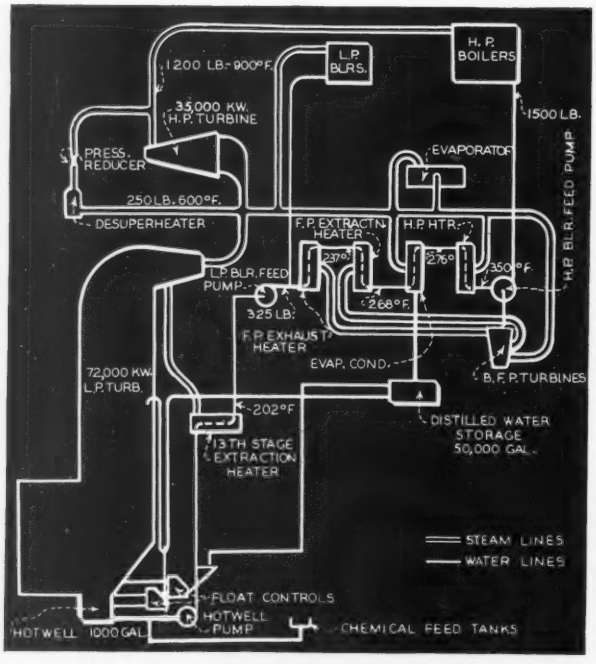


Fig. 1. Diagram showing the feedwater cycle. This is a diagram which shows the arrangement of the new high-pressure boilers and turbine, the pressure reducer, and de-superheater, the new feedwater heaters, evaporators and high pressure boiler feed pumps and how they will be tied into the present lower pressure equipment

These two units were put in service in the summer of 1918 and were followed in 1920 and 1921 by two additional units which brought the capacity of the station to 100,000 kw. in four turbines supplied by 14 boilers.

In 1928 and 1929, these four turbines were rebuilt, new diaphragms were installed in the first 11 stages and a 13th stage extraction heater was installed and new generators of 45,000 kv-a. each were installed. The rating of the rebuilt turbines was thus increased to 36,000 kw. each and the rating of the station increased to 144,000 kw.

During the next three years, we had a more or less continuous recession in our system load which decreased from 187,000 kw. in the fall of 1929 to 148,000 kw. in the summer of 1932—a decrease of approximately 20 per cent. Since 1932, the load has increased in uncertain and unpredictable steps until at the end of 1935, the Cincinnati peak was 206,000 kw. or 10 per cent above the peak of 1929.

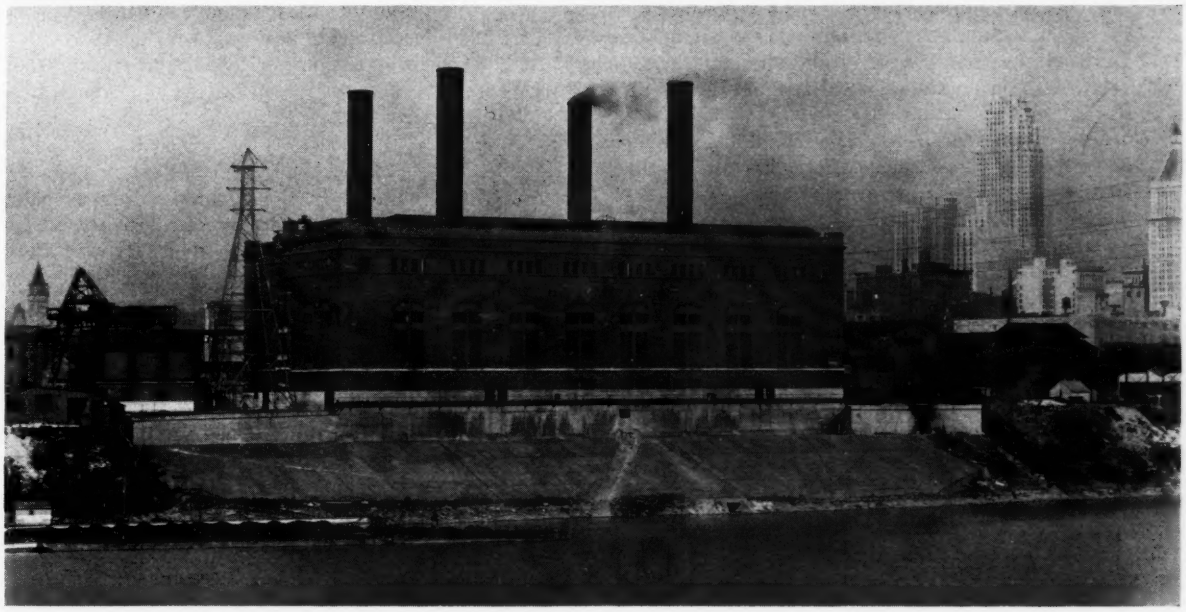
This increasing load required that engineering studies be made of new generating capacity and near the end of 1935, a decision was made to proceed with a 35,000 kw. superposed unit for West End Station. The steam for this new unit will be generated by three boilers and supplied to the turbine at 1200 lb. pressure and 900 deg. F. total temperature. Steam from this unit will be exhausted at 260 lb. pressure into existing turbine headers and will then pass through the present machines to the condensers.

Design

In designing and laying out this new equipment, a prime consideration is to make use, in so far as economically possible, of existing building structure and equipment. For example, the width of the boilers is such that they fit in between existing building columns just as well as the original boilers did.

In order to make room for the three new boilers and the new turbine, four old boilers are being removed from the southwest corner of the boiler room. The new turbine will be located as close to the present turbine room as possible and on the same floor level and parallel to the present turbines.

for West End, Cincinnati *



The present wall between the turbine room and boiler room will be removed so that the operation of the new turbine can be readily combined with the operation of the two present units.

Cottrell precipitators or dust collectors will be located on the building steel which formerly supported the economizers. The ash handling system has been laid out so as to make use of one of the old coal cranes, which will be displaced by the new coal handling equipment.

Coal Handling

The present coal handling equipment is of the open type and coal is brought into the station in side dump cars and emptied into pits from which it is handled by overhead cranes with clam-shell buckets and dropped into the open bunkers above the stokers. While this system is quite reliable and is operated at low cost, it is extremely dirty and coal dust travels to all parts of the plant. This system is also affected by high water and it would be quite a problem to operate it with the river stage above 65 ft.

The entire inside coal handling system will be displaced by new closed type overhead bunkers, supplied by belt conveyors and arranged to supply coal directly to the existing stokers which will be left in the station, as well as to the new pulverizing mills. The coal conveyor equipment outside the station will be so arranged as to be independent of high water. Every effort will be made to minimize coal dust and confine it to the coal handling system so that it will not be spread through the plant.

Each boiler will be direct-fired with pulverized coal by two size 232 Babcock and Wilcox pulverizers. Each of these pulverizers will have a capacity for pulverizing ten tons of coal per hour. Coal to each pulverizer will be weighed automatically by a Richardson scale located in the coal duct between the coal bunkers and the mill. The supply of coal to each mill will be regulated by a Bailey feeder.

Pulverized Fuel Equipment

The pulverizing mill consists of a double row of balls driven from a vertical shaft by a constant speed motor. Primary air drawn from the air heater is blown through the mill and carries the finely pulverized coal to the furnace. This air is supplied by a motor-driven fan and, in addition to carrying the coal from the mill, supplies sufficient heat to dry the coal in the mill.

Primary air and the coal which it carries in suspension is admitted to the furnace through a burner which divides the coal and air into a number of narrow streams and discharges them into the furnace between the water tubes which form the roof of the furnace.

Secondary air is admitted at the burner through an inlet box which entirely surrounds the burner proper. Thus all coal and air necessary for combustion are supplied at the burner. Each mill supplies two burners and there will be four burners installed across the front of each boiler.

Three steam generating units are being installed with the turbine. Since the steam supplied to the high-pressure turbine will in turn be supplied at reduced

pressure to two low-pressure turbines, it was considered desirable to supply the steam from three units —no one of which was larger than the capacity of a turbine—in order to insure maximum availability of steam supply. This determined the maximum capacity of a boiler to be 350,000 lb. per hr. and the high duty, integral-type boiler selected for this job is a low and compact unit which is being installed in the existing building with minimum changes to the building steel.

The steam drums on these units are designed for 1450 lb. working steam pressure and the superheaters are designed for a maximum total temperature of 925 deg. F.

Burners will be arranged for vertical firing and a new design of slag tap furnace, capable of handling coals with ash fusion temperatures varying from 2400 to 2800 deg. F. will be used.

The walls and floor of the furnaces will be of full-stud tubes covered with chrome ore. The slag opening will be near the center of the floor and arranged for continuius slag tap.

Between the furnace and the superheater are two vertical open passes of partial stud tube construction which present a high heat-absorbing surface for rapidly cooling the gases and eliminating the necessity for a bank of tubes which may become slagged.

Ash which collects in the first pass will drop to the bottom and melt on the furnace floor. Ash from the second pass will fall into an ash hopper at the bottom of the superheater. This arrangement of vertical passes eliminates all possibility of direct radiation from the furnace to the superheater. This should prevent any slag from sticking to the superheater and result in easily cleaned convection surfaces throughout the unit.

The superheater extends about 80 per cent of the distance across the unit and the remaining 20 per cent is a section of the economizer equipped with a vertical baffle so that the gases can be completely shut off from this economizer section. This will permit a reasonable amount of superheat control at all loads and is of particular value in controlling the temperature at the exhaust of the high-pressure turbine.

These slag tap furnaces have a high combustion efficiency and allow for the greatest recovery of ash in the furnace, which should result in cleaner convection surfaces. The vertical firing provides rapid and complete combustion with high-heat releases and maintains the slag at a high temperature, which results in easier tapping. Since the ash fusion temperature is as high as 2800 deg. F., this is very desirable.

At 350,000 lb. of steam per hr., the heat liberation in the complete furnace including the open passes, is 56,000 B.t.u. per cu. ft.

Ash Handling

Ash which collects in the furnace or drops back into the furnace from the first vertical pass will be fused to a liquid on the furnace door. It will then drip continuously through an opening near the center of the floor into a tank of still water located in the basement underneath the furnace. The quenched slag will collect in this tank and will be flushed intermittently into a sluice. Dry ash which may collect in the large hopper underneath the superheater will be discharged intermittently into this same sluice.

Fine dust or fly-ash which passes through the boiler and air heater will be collected by an electro-static precipitator located above the boilers. This fine material will be collected in hoppers and discharged intermittently into the sluice.

The sluice will carry the slag, ash and dust into a pit at the east end of the boiler room, where it will be removed by a clamshell bucket and loaded into railroad cars for disposal.

Turbine

The new high-pressure Westinghouse turbine is rated at 35,000 kw., with a maximum rating of 40,000 kw. when supplied with steam at 1200 lb. gage and 900 deg. F. total temperature and operating with 260

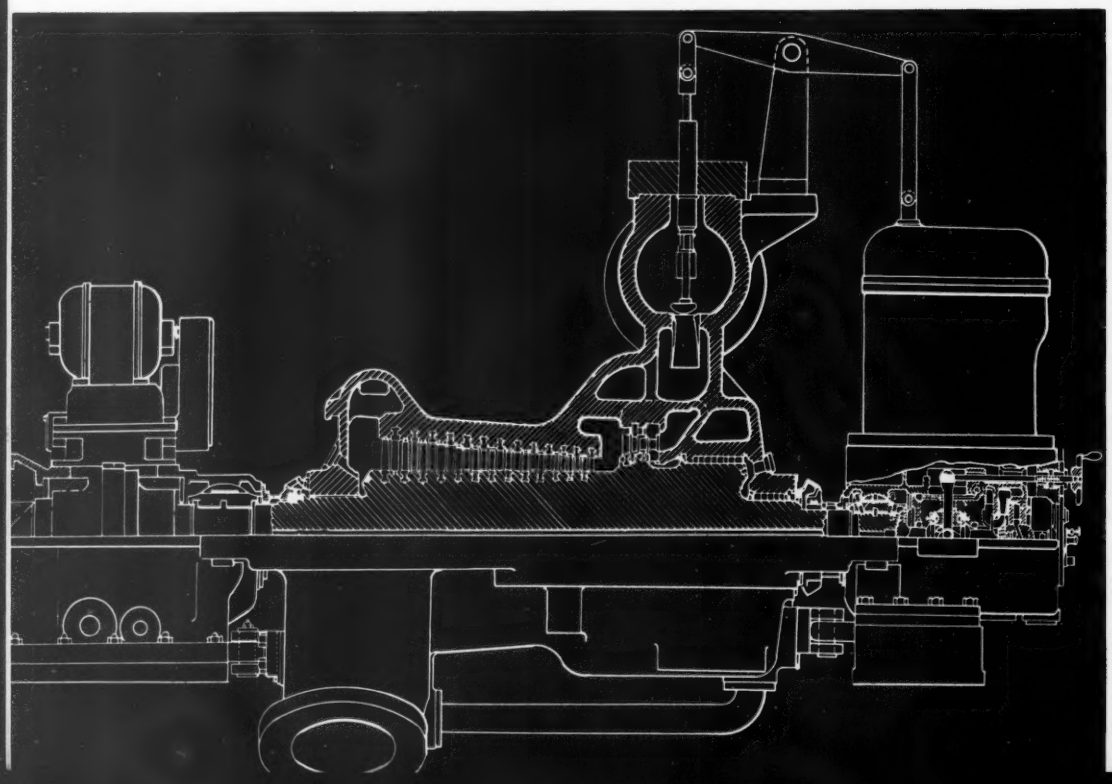


Fig. 2. Section through the main 35,000 kw. turbine unit. The operating governor is enclosed in the dome on the right and linked to the control valves in the steam chest which is in the top of the upper cylinder casing. The Curtis element and reaction stages are clearly shown.

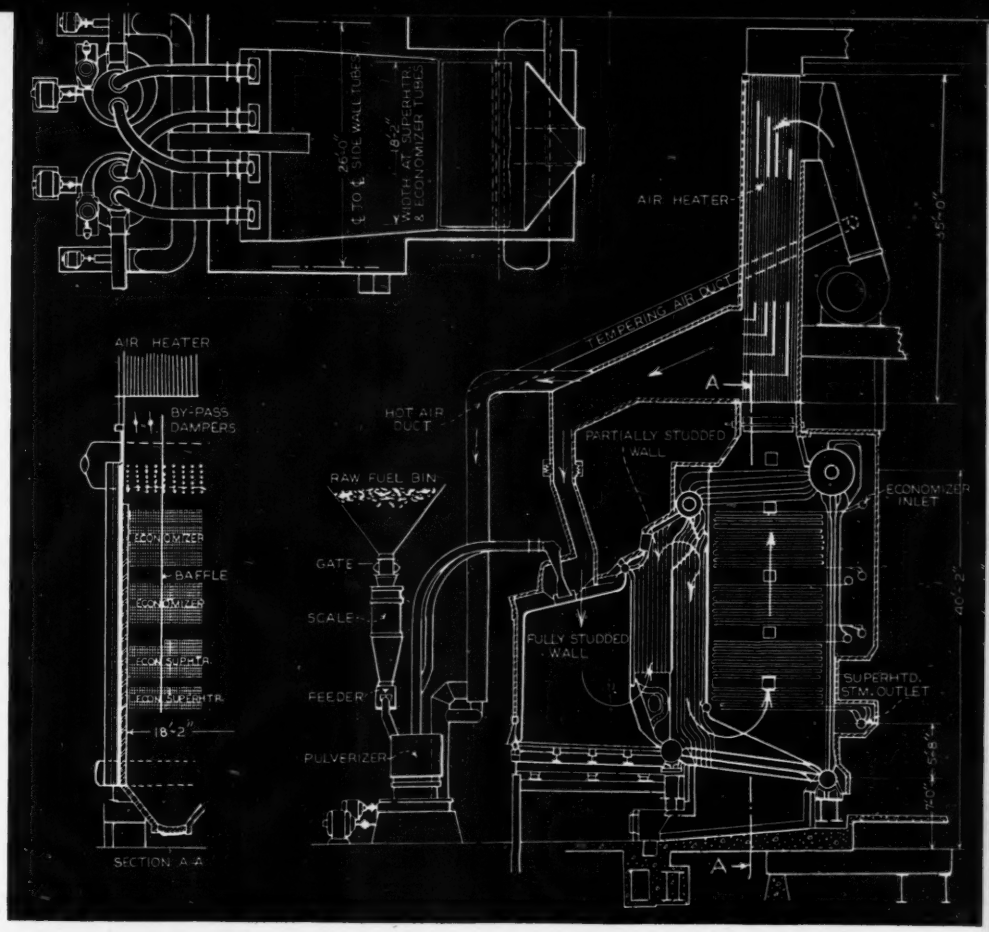


Fig. 3. Boiler, air heater and pulverizing mills. The sectional side view shows the location of the furnace. The burners are of the vertical intertube type. Slag will be tapped continuously from the center of the furnace floor, but slag handling equipment is not shown in this drawing.

Flue gases pass out the top of the air heater to the Cottrell dust collector and the induced draft fan, which are not shown in the drawing.

Section AA shows vertical baffle and by-pass damper for controlling superheat.

lb. gage back pressure. The exhaust steam from this unit will be supplied to the present low-pressure turbines and the size of the high-pressure unit has been selected in order to supply two low-pressure units.

Steam is admitted to the turbine through a 20-in. throttle valve with the oil-operating mechanism located below the steam inlet so that no oil can leak on to the steam piping. From the throttle valve, the steam is led through two 14-in. pipes to the ends of the steam chest which is located on top of the cylinder. Seven control valves operated in series by a bar lift admit steam through diffuser-type bushings to the nozzle inlet.

The control valves are actuated through an oil relay system by an hydraulic type governor which consists essentially of an impeller mounted on the turbine shaft which discharges oil at a pressure varying as the square of the speed. The blade path consists of a Curtis-type impulse element and 13 stages of reaction blading. Steam is admitted to the impulse element through the first six control valves. The seventh valve admits steam directly to the reaction section and is essentially an overload valve.

The cylinder casing is of cast carbon-molybdenum steel. The rotor is a forging of nickel-chromium-molybdenum steel and has a drum diameter of 22 in. The length of the unit between bearings is approximately 10 ft. The blades are made of stainless steel and the largest ones are approximately 5½ in. high.

When operating at 3600 r.p.m., the peripheral speed of the blades is 532 ft. per sec. The turbine and generator rotors are solidly coupled together and the unit is equipped with a motor-driven turning gear which will revolve the spindle at 5 r.p.m.

Piping

The principal problem in connection with the piping installation is that produced by the temperature of the steam. This will normally be 900 deg. F., but may go as high as 925 deg. F. at times. The pressure in the main line will be 1200 lb. per sq. in. and in the feed water lines will be as high as 1600 lb.

The factors of time, temperature, and stress and their effect on the behavior of metals have been given consideration for some years. In addition to these factors, we must also consider the composition of the metal and also the character of the atmosphere surrounding it. In order to obtain more information about the behavior of various materials in contact with high pressure, high temperature steam, the A.S.M.E. Research Committee is guiding some studies now being undertaken at Purdue University under Dean Potter. In refinery work where sulphur is present, considerable use is made of an alloy of 4 per cent to 6 per cent chromium. This same material will not necessarily be entirely satisfactory under high temperature steam conditions and some metallurgists feel that molybdenum should be used and others tungsten. For our piping, we are proposing to use carbon-molybdenum steel containing approximately ½ per cent molybdenum.

Similar material will be used for the steel castings in the high-pressure turbine shell and also in the valve bodies and corresponding equipment.

It is of interest to note that most of the valve manufacturers are using stellited seating faces and the seat rings on the high-pressure, high-temperature valves are welded in. Most of the valves will be welded into the pipe lines and the piping itself will be almost entirely welded. The only flanged joints will be those which must be broken from time to time in order to make turbine inspections or do similar work.

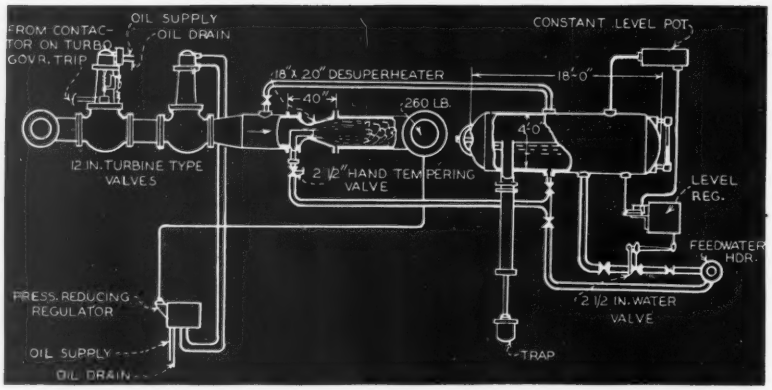


Fig. 4. Pressure Reducer and De-Superheater

When the new high-pressure turbine is operating and delivering steam to two low-pressure turbines, we have fundamentally a single cross-compound unit having a rated capacity of 107,000 kw. If the unit were simply operated in this manner, the loss of the high-pressure turbine or its generator would immediately involve the loss of the other two units and a very considerable amount of generating capacity would immediately be lost to the system.

Pressure Reducer and De-Superheater

In order to prevent the loss of so much generating capacity, we are providing a by-pass around the high-pressure turbine which will be designed to pass sufficient steam from the high-pressure boilers to operate the two low-pressure turbines in case of an outage of the high-pressure turbine. This by-pass arrangement consists of a quick-opening valve, a reducing valve which will reduce the pressure from 1200 lb. to 260 lb. and a desuperheater which will reduce the temperature from 900 F. to 600 deg. F.

The quick-opening valve will normally be closed, but in case of an outage of the high-pressure turbine it will open wide, automatically, in less than one second and provide a continuous and uninterrupted supply of steam to the low-pressure turbines.

The pressure reducing valve and de-superheater are necessary in order to supply the low-pressure turbines with steam of the proper pressure and temperature.

Boiler Feed Pumps

The Worthington Pump and Machinery Corporation are building three 6-in., six stage boiler feed pumps of the centrifugal type to be driven by 1500 hp. General Electrical turbines.

These pumps are designed to handle water at 380 deg. F. and with a suction pressure of 275 lb. will pump 1200 g.p.m. at a discharge pressure of 1600 lb. Two pumps will have sufficient capacity to handle full load on the high-pressure unit, and the third pump will be a spare.

They will be direct connected to the turbine drives and operate at 3500 r.p.m., and the turbines will use steam at 250 lb. pressure, 600 deg. F. temperature. The turbines will operate with 10 lb. back pressure and with extractions at 30 lb. Both the exhaust and extraction steam will be used in closed heaters for feed water heating. The use of auxiliary turbines of of this type is rather unusual, since in most stations using the regenerative cycle, steam for feedwater heating is obtained by bleeding the main units.

Our present turbines have only one point of extraction and this already is being used to heat the feed water to approximately 200 deg. F. Since it is practically impossible to provide extraction openings on a unit already built without them, we felt that the best way to obtain a cycle equivalent to two additional extraction points on the low-pressure units would be the use of back pressure extraction turbines which drive the high-pressure feed pumps.

Since something over 1 per cent of the energy generated in a 1200 lb. steam cycle must be used for pumping feed water, these auxiliaries are large enough to provide sufficient exhaust heat to raise the temperature of the feedwater to 350 deg. F. under normal conditions.

Feedwater Heaters

With our present arrangement of equipment, condensate is pumped from the hot-well through the 13th stage extraction heater and delivered to the present boiler feed pumps at 200 deg. F. and these feed pumps raise the pressure to 325 lb. for the boilers. With the new arrangement of equipment, the water from the present boiler feed pumps at 325 lb. and 200 deg. F. will be passed through a series of four feedwater heaters by which the temperature will be increased to approximately 350 deg. F., and at this temperature will be delivered to the new high-pressure feed pumps.

The first of the four heaters takes steam at 10 lb. pressure from the exhaust of the boiler feed pump turbines. The second heater is supplied with steam at 30 lb. from the extraction of the boiler feed pump turbines. The third heater receives steam from the evaporator and the fourth heater receives steam at 260 lb. from the exhaust of the high-pressure turbine.

This arrangement of closed type heaters makes a quite simple system of feed water heating since there are no water levels to control and the operation is entirely automatic and the amount of heating depends entirely upon the heat head available at each heater.

Make-Up Water

In any steam cycle using surface condensers, there is always a certain amount of loss of steam or water through leakage, soot-blowing, boiler blow-down or changing the water in the boilers. In our cycle, we assume that these losses will amount to approximately

2 per cent and this amount of make-up water will be distilled by evaporators.

In our case, the steam supply will be at 250 lb., 600 deg. F., and the water to be evaporated will be treated water from a cold intermittent process lime and soda softener. Chemically softened water such as we now use for make-up water has a hardness of ¾ of a grain per gallon and the total soluble salts will run at least 20 grains per gallon.

Boiler Water Conditioning

Experience in various power stations has indicated the desirability of maintaining higher pH values of the water by the use of various chemicals. For instance, we will expect to operate the boilers with a concentration of 2 to 5 grains per gallon of sodium hydroxide. If a boiler contains less caustic than this, more will be added and if the concentration should increase above this amount, it will be reduced by blow-down. This concentration of sodium hydroxide is considered sufficient for the protection of boiler metal against corrosion, but in order to prevent embrittlement of the boiler metal, it will be necessary to have a sulphate concentration at least three times as great as the caustic concentration.

In order to counteract any traces of free oxygen which might be dissolved in the water, we will add to the condensate a small amount of sodium sulphite. The sulphite combines with free oxygen to form sodium sulphate so that there is a double advantage in the use of sulphite. First—it combines with any traces of free oxygen and thus prevents corrosin. Second—the sulphate formed by the combination acts as an inhibitor of embrittlement.

There will be a certain amount of leakage of raw river water into the condenser hot-wells through the condenser tube fastenings. In order to neutralize the hardness which will be added to the water in this way, we will feed sodium phosphate into the system. The phosphate will react with any calcium or magnesium salts which enter the boiler to form an insoluble phosphate which will not cling to the heating surface and in this way, scaling is prevented.

These chemicals will be added by continuous feeding into the hot-well pump suctions in order to increase the pH value of the condensate and protect as much as possible the piping and the closed heaters.

The water conditioning will be supervised by Hall Laboratories, of Pittsburgh.

This may seem like the addition of a large amount of chemicals to the boiler feed water, but in fact the additions are rather small and the maximum concentration of salts which we would expect to have in the boiler would be approximately 30 grains per gal. This concentration is not greatly in excess of the amount of salts carried in the Cincinnati drinking water.

Conclusion

In presenting this picture of the generating unit, I have had in mind not so much a description of the physical equipment as a summary of the principal engineering features involved. If we only consider the engineering developments of the past six years, which have made certain features of this installation possible, we will find that it will be no small part of the design.

For instance, the coal will be pulverized without pre-drying. The coal will be burned at a rate per unit of furnace volume at least four times as great as it is in our furnaces at Columbia Power Station, which were installed in 1925. Fly ash will be recovered from the flue gases by an electro-static system which, while not unknown six years ago, was almost prohibitive in cost.

The arrangement of heating surface in a boiler unit so that the superheat can be varied without regard to load is a recent development. The design of superheater, piping and turbine for 925 deg. F. steam temperatures has only been made possible by recent metallurgical developments.

Advances in the technique of welding in recent years have made possible the use of continuous tube superheaters and economizers; the use of high-pressure boiler drums, at a reasonable cost; the erection of a high-pressure piping system, without prohibitively costly joints; and has simplified the design and greatly improved valves and fittings.

Large high-speed turbo-generators, such as this one, are also dependent upon improvements made by the steel companies in turning out large forgings. These forgings have to meet very rigid specifications which a few years ago could not have been met.

When one considers the features of this generating unit as compared with a unit of six years ago, he can not help but be impressed by the great number of engineering developments which have taken place during the past six years.

Fig. 5. Photograph taken from the roof of the present station showing the beginning of construction work. In the foreground are the piers which are being built to support the new switchboard

Use Value *of* Coal *for* Steam Generation*

Price of Coal f.o.b. Plant Is Only One of the Many Factors Involved in the Selection of Fuel, Their Costs Range from 6 to 20 Per Cent of the Cost of Evaporation

By C. C. Wilcox, Studebaker Corp., and J. W Nash, Bendix Prod. Corp.

GENERAL reduction in maintenance and rehabilitation programs resulting from recent economic pressure has brought about an increasing amount of attention to possible economics in steam generation by broad consideration of the fuel problem, resulting in keener competition between fuel sources of all kinds and a very effective and healthy scrutiny of all manner of fuel use problems.

Exhaustive and able research has been carried on by many fuel and combustion specialists, as well as designers of equipment in the art of burning fuel, and the results of these highly specialized investigations have been placed at the disposal of the users of fuel.

With these efforts on the part of the producer to assist in proper selection and the fund of information yielded by research to aid the user in understanding the processes involved in the combustion of coal, it would seem that the purchaser could proceed with certainty to the correct answer. And so he can, except for a number of incidental costs which affect the use value of coal and which he will have to determine for himself.

In addition to fuel cost f.o.b. plant consideration should be given to the following items of incidental cost as effecting use value:

Unloading and handling, crushing, stock pile loss, refractory loss, ash handling cost, tube slagging cost, dust, sifting loss, damage to heat recovery equipment and breeching, back smoking, reliability of source, multiplicity of sources, reciprocal trade agreements, evaporation obtained and cost accounting.

The above items properly evaluated together with the evaporative results obtained should pretty well determine the relative use value of the coal. They range from a minimum of 6 per cent to a maximum of 20 per cent of the cost of evaporation.

Fuel Cost f.o.b. Plant

This is usually the largest single item of cost, and since it is of very definite value it is easily remembered by the operator or purchasing agent, and so may be given more than its proper weight. It is the function of the purchasing agent to make the survey of sources of approved coals and to take proper cognizance of competitive prices. This requires close and constant attention, however, because of the complexity of the factors involved. The relative weight of consumer preferences is a constantly changing pattern and one in which is reflected all the contributing influences of plant and load changes of the consumer group, so that the physical characteristics of a coal does not finally determine its price.

It is interesting to note in this connection that sometimes the use value of even a refuse fuel may be so low on account of the incidental costs that its burning becomes more a matter of disposal than of steam generation. This illustrates the importance of the fact that the operating engineer's opinion and decision should be obtained by the purchasing agent before a contract for fuel supply is consummated.

The preparation of the coal to be purchased should be specified by the engineer in charge of operations as the type of equipment available for handling and burning the fuel will determine its classification and grade.

Unloading and Handling

In a large measure the coal handling equipment determines the importance of this item, but other factors enter the problem that are sometimes of considerable magnitude. Usually the coal can be, and is, shipped in cars that suit the consumer's preference, but if for any reason the producer fails to do so, or if so-called "spot" coal is being considered this must be taken into consideration. Moisture content may more than double the cost of unloading in winter. The difficulty of unloading frozen coal is still fresh in the minds of many plant operators, and mutilated cars bear testimony to the methods that were used. A high moisture coal would have a higher use value in Alabama than Wisconsin during the winter season, other things being equal.

Crushing Cost

Certain Indiana coals for instance are very hard to crush, and unless appropriate equipment is at hand such coal might be ruled out, or if used at all would entail considerable crushing expense. These same

*From paper before Midwest Power Engineering Conference.

coals, however, have some economic advantages and as a result there is a constant demand for them. This has led to the installation of crushers at the tipple and so the circle of adaptability of these coals has widened. The whole matter is intimately involved in the standardizing and simplifying of coal sizes, and as this phase of the industry is improved and developed the necessity for reduction at the plant will diminish.

Stock Pile Loss

In many industries the storage of coal to cover periods of anticipated interruption in shipments is found desirable. If storage space is cramped and rehandling impractical, stock pile fires are damaging and sometimes very costly. Most coals with fines, high in sulphur and volatiles, stored to heights over 10 ft. are liable to heat and ignite, and stock pile loss must be considered in arriving at the use value of this coal. It is usually found that the only way to put out a stock pile fire is to burn it under the boiler as fast as possible. This entails premature rehandling cost and always results in lower evaporation than realized in fresh coal as purchased. As a rule the coals highest in volatile suffer the greatest deterioration in storage even if heating is not a serious factor. Thus the use value for storage depends upon its own peculiar factors and oftentimes the storage of only high grade low volatile coals can be considered even though another grade which will not store is most economical for current consumption.

It has been found that where hot storage coal is handled on belt conveyors the damage to belts is excessive, and may in a few days cause wear and tear equivalent to a year of normal use.

Casting Loss

This applies particularly to stoker fired boilers and refers to the destruction of stoker metal parts due to the action of coal slag or too high metal temperatures. At high temperature steel and iron have quite an affinity for the sulphur of molten ash. Due consideration must also be given to the chemical composition of the ash as certain compositions have a tendency to act as a flux and lower the melting point of the cast iron with the resultant formation of iron oxide of the higher form and cause the ultimate disintegration of grate bars. It is not difficult to understand that, in a furnace carrying a temperature of 2800 deg., it would be easily possible to get stoker castings under certain conditions up to a red heat, at which trouble begins. This item is of sufficient importance to become a factor in the selection of fuel burning equipment, and in any existing plant it cannot be ignored in the selection of fuel. Casting loss may result from grate exposure to radiant heat due to insufficient ash for protection at the back end of the stoker and is then sometimes accompanied by excess air losses as well. The maintenance cycle is usually long enough to hide the ill effects of poorly selected coal for a time, but if the combustion rate is high and conditions severe, trouble may become apparent in a few hours.

Excessive grate loss has been experienced in the past when fuel preparations have been changed to that which was unsuitable to the ratio of air space to grate bar area, necessitating the replacement of grates or links of a different ratio because of the inability to secure the proper fuel.

Refractory Loss

Chemical and metallurgical reaction is more pronounced with the low fusion coals and has received much consideration by equipment manufacturers who have designed furnaces to burn this grade of coal. Large furnace volume with low heat release and air cooled walls are prominent in this design on the one hand, and water cooled walls with higher heat release on the other. In each case the avoidance of refractory maintenance is one of the principal objectives. The increasing number of plants designed to burn coals without refractory loss will again result in a shift of consumer preference and a corresponding change in price pattern of these coals.

Ash Handling Cost

In the routine of firing boilers a portion of the ash handling cost may be easily hidden. In the dumping type of underfeed stoker the time necessary to clean fires depends upon the character of the refuse produced. This cost is roughly proportional to ash content and is increased by low fusion. If there are no clinker grinders then clinkers must be reduced to manageable size before final disposition, and this must be included in the cost. If damage occurs to ash handling equipment further cost is entailed. The refuse may have a sufficient market value to defray cost of handling. Heavy fused clinker and very fine ash each presents its own problem of disposal, and the answer is not complete till all the costs have been counted after the refuse finds its final resting place. It is well known that the removal of fly ash is dangerous and proper protection must be provided in handling it.

Tube Slagging Cost

If by reason of low ash fusion temperature, extreme activity of fuel bed or both, the tubes of the boilers slag over, then the use value of the coal is less than would be inferred from the calorific value as determined by calorimeter, and the heat which we can realize is very disappointing. We may start with very clean surfaces but, with each successive hour of operation, boiler efficiency and capacity fall off, and an economic balance is soon reached at which an outage for cleaning is justified. Molten ash adhering to the first row of tubes is, as a rule, not in a position to be removed by soot blowers even if loose enough to respond to this method of cleaning, and it often is not, hence rodding or some other method of removal is necessary. This requires outage of the unit with the attendant losses of dropping it and bringing up a new boiler. Slagging, of course, is influenced by furnace design through such features as slag screens, control of gas velocity and direction of firing, and the presence and effectiveness of these features increases the use value of coals which possess this characteristic. If the plant load has outgrown design capacity the entire pattern of coal values may change, so that a fuel which showed no marked tendency to slag under normal conditions

becomes unmanageable at higher ratings, and coals formerly ruled out on account of price may move into the approved list in conformity with the shift in use value.

Sifting Loss

During the pre-ignition of many stokers, the fines fall through the grate and require further handling or automatic arrangement made for their disposition. This item is not, as a rule, large or very troublesome, but it is a nuisance anywhere and requires attendance. Naturally the fewer the fines the less the sifting, but a certain percentage of fines usually is desirable for other reasons.

Sifting losses are reduced to a minimum on some equipment by tempering the coal, in other installations the fines may be reduced to the optimum point by the purchase of coal of the proper preparation, or having suitable coking characteristics.

Plants in which stack gases are reduced below the dew point of water and SO_2 must be prepared to cope with corrosion of heat recovery surfaces and when coals high in sulphur are burned, considerable maintenance expense is entailed. Of course provision can be made to combat this at least partially by protective coating of these surfaces, but in any event the coal characteristic adds to the incidental costs of burning it in one way or another, and so reduces its use value. Plants in which stack gas temperature is above the dew point do not experience much difference in use value in this respect.

Back Smoking

Inadequate draft or improperly adjusted blast dampers, excessive or premature coking or clinker formation on furnace walls may be contributive to production of hopper gas, but in many cases it persists after the above causes have been removed as far as possible. It is then sometimes found that the coal has too small a percentage of fines and the trouble disappears entirely when fines are introduced into the hopper. The elimination of hopper gas certainly would add to the use value of any coal in a plant where this difficulty is present. It is well known that coal is crushed and compacted to a degree in passing from the hopper to the retort of an underfeed stoker and that as a result the fines are increased and at least a partial step made toward elimination of hopper gas.

Reliability of Source

It is true adequate storage minimizes the chances of such a shortage arising, but it is just as true that storing coal is expensive when viewed from any angle, so that a source which has been proven reliable certainly contains an element of value that cannot be overlooked. The cost of a given interruption arising from failure of coal supply would be comparatively easy to evaluate but it would be difficult to ascribe a per ton value to reliability over a period of time. The good judgment of the user must be depended upon here as elsewhere.

Overzealous selling sometimes secures an order for coal that cannot be shipped in time to be of maximum value. Poorly maintained mining equipment or partially depleted sources may contribute to irregularity of output or quality of coal and so entail consumer expense in maintaining stocks to protect plant schedules.

Loss by Multiplicity of Sources

Many plants regularly use coal from a single source and the problem is continually arising as to whether another coal having certain attractions shall be considered as an auxiliary fuel. Quite aside from the evaporative results the second coal may offer, there are sometimes incidental costs arising from handling two grades of coal rather than one that may not be appreciated. To start with they should as a rule be stored separately and oftentimes this is unpractical. In most installations they should not be burned simultaneously in the same furnace, and if so they should be separated in the bunker, which is likely to reduce bunker capacity. If the two coals are grouped by the railroad in final delivery at the plant care must be exercised in the order of selection of cars for unloading according to storage or bunker space available at the time, or the burning requirements of the respective coals. Where this precaution is necessary delay and expense are sure to follow.

Where a reliable source of fuel is available it is advisable in the average plant to use this supply as it simplifies operating conditions and tends to maintain plant operating efficiency. It reduces the excuse of the operating crews for poor results on a shift and keeps a better morale in the crew.

Reciprocal Trade Agreements

A well recognized and for the most part a justifiable technique in purchasing transactions is operation of the reciprocal trade agreement. While this may run crosswise to technical considerations of selection and seldom originates with the operating engineer, it sometimes is thrown into the well ordered and smooth running tests of the engineer as a sort of eleventh hour monkey wrench. The smaller the percentage of coal cost to total plant or factory operating cost the more potent is the reciprocal trade agreement likely to be, and when the coal cost is a relatively large item greater weight must be given to the engineer's recommendations and the effect of coal selection on any other than a strictly engineering basis must be carefully appraised and forecast.

Reciprocity might and sometimes does outweigh the other factors in coal selection and so might easily dominate in arriving at maximum use value.

Dust

For domestic use a dusty coal is always offensive, and in most of the small commercial plants it is becoming a factor of increasing importance in the selection of coal. Dust in any power plant is a nuisance and entails very definite operating costs. As a result pretreated coal has grown in popularity and there is now available the dedusted coal which costs a few cents a ton more than the raw coal but which in many instances lends a decided increase in use value.

Both calcium chloride and oil have figured prominently in the treating of coal for the combating of dust but we are not here considering the treatment of coal by the chloride or any other process which has for its object the improvement of combustion efficiency only,

because the value of any such treatment as an aid to combustion would show up in the evaporation obtained, and since its cost would be included in the f.o.b. price of fuel at the plant its justification from that standpoint would rest on the boiler trials. Pretreatment has also been used to prevent freezing and when so applied would add to the use value from the standpoint of unloading.

Evaporation Obtained

This characteristic of coal receives the lion's share of attention in making a selection, and justly so, but in arriving at a final answer all of the incidental costs and considerations above referred to must be taken into account as an addition to the per ton cost of the coal. Fortunately the evaporation can be found by test over a comparatively short period of time, usually not over 24 hr., or sufficient to go through the complete cycle of load changes in one day's operation. The heating value of coal, its ash content, the fusion temperature of ash, the size and grading of the coal, its uniformity, or nonuniformity, its moisture, ease of ignition, coking tendencies, coke tree characteristics, etc., are vital factors affecting the efficiency of combustion and the combination of all these factors is the resultant which eventually determines the equivalent evaporation per pound of coal as received as shown by boiler trials. The quantitative effect of each of these items has received exhaustive study and the part each plays in the combustion of the coal and contributes to the final result is becoming better known all the time, but no matter how thoroughly and completely they are catalogued and analyzed the chances are very much against picking the right coal from a consideration of its laboratory analysis only. The final test must be its use under operating conditions, in which all the incidental costs are observed and recorded.

Accounting

In order properly to evaluate the different factors which have been enumerated above as entering into the selection of coal it is necessary that a good system of accounting be used so that the operator of a plant can tell at any time just what the relative importance of these various items of cost has been. As indicated elsewhere, the period of the maintenance cycle determines the length of time which a given coal must be under observation in order to arrive at anything like a reliable estimate of the size of these incidental costs and a complete and accurate record of maintenance costs must be kept throughout the period so that the result of operations under the use of several different grades of coal which are being considered can be intelligently compared.

It is seldom that the accounting department appreciates the necessity of subdividing the accounts sufficiently for the purpose of ascertaining use value as required by the operator. The charging of time and material must receive the closest personal attention of the operator in charge as well as the intelligent coöperation of the operating forces, and if such an accounting system is not in force he must insist on appropriate changes or additions to it or keep his own records, as is usually necessary in the small plant.

Efficient Colored Light

A NEW KIND OF LAMP, developed in the research laboratories of the Westinghouse Lamp Company here, changes invisible ultraviolet radiations into visible light of all the rainbow colors and from 50 to 120 times more plentiful than by present-day methods. The phenomenon of fluorescence, by which invisible radiations of short wavelength are transformed into visible light, is the secret of this new invention.

"A small globule of metallic mercury is vaporized by electricity until it fills a long, slender tube with a dull glow which is rich in ultraviolet radiations," explains Dr. Roy D. Hall, Westinghouse engineer. Profuse ultraviolet radiations from this arc strike the inside surface of the tube where a coating of chemical powder transforms them into visible colored light, in a sense producing second-hand light."

In reality, the lamp is merely stretching short radiations until they are long enough to be seen. Ultraviolet radiations are of such short wavelength that the human eye cannot see them. Hence, they lie outside the spectrum of visible light. But when these invisible ultraviolet rays fall on various minerals and chemicals, they are transformed, or "stretched," into visible light. Its color is governed by the characteristics of the chemical substance.

"Knowing how certain chemicals and minerals react to ultraviolet radiations, we can select the one to produce a desired color and use it as the powdered coating on the inside of the glass tube," explains Dr. Hall.

100 Times More Efficient

"This transformation is the reason for the greater efficiency of these lamps as sources of colored light. Tungsten filament lamps produce light containing all colors of the spectrum, but to get any one color, all the remaining colors must be removed by filtering, which means wasting them.

"In a blue bulb, for example, only the blue rays of the tungsten light are seen by the eye. The rest are filtered by the blue glass which will transmit only the blue rays.

"These new lamps therefore produce colored light at many times the efficiency of tungsten lamps. When consuming 15 watts of electricity they give more colored light than a 60 watt colored tungsten lamp of similar size."

Research into this new method of light production to date has been confined to the lumiline shape of bulb, the long, slender tube which is sealed at each end by a disc-like base. However, engineers envision widespread use of this type of colored light for decorative purposes when it finally emerges from the laboratory. They say that it will probably be bent into various shapes to form luminous designs for interior decorations.

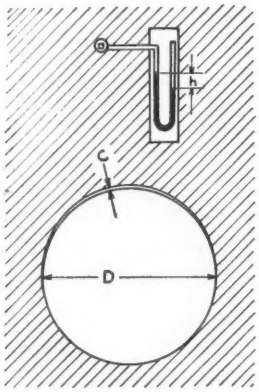
Like the present lumiline lamp, it will probably enjoy widest use placed end to end to form a continuous line of light. Producing light entirely by fluorescence, it is not to be confused with the various type of filamentless lamps used in advertising signs and generally classified as "neon."

Reducing that "Unaccounted for" Loss

Leakage Loss Around Mud Drum Warrants Attention in Accurate Boiler Tests

By P. E. MOHR*

USUAL BOILER Heat Balances do not include leakage losses except under that all-inclusive term "Unaccounted for" loss. Plant operators who are interested in reducing costs will do well to determine the extent of leakage losses such as those occurring around the mud drums of bent tube boilers. A sample calculation for the evaluation of heat loss due to leakage around the mud drum follows with a formula for the estimation of such leakage loss included.



Air loss through crack C should be considered by engineers interested in reducing the usual unaccounted for loss in the boiler test to the minimum value

To determine the maximum width of the crack between the mud drum and the brick work, assume a maximum working pressure of 400 lb. per sq. in. gage (448 deg. F.), a tube length of 20 ft. and an installation temperature of 60 deg. F. The maximum tube expansion due to temperature changes will be: $20 \times 12 \times (448\text{-}60) \times 0.000{,}006{,}7 = 0.624$ in. From the A.S.M.E. Code list of tubes suitable for the assumed working pressure, a 3¾-in. tube with 0.180-in. wall thickness is found to give a maximum elongation due to internal pressure. This maximum elongation is 0.01672 in. giving a total maximum width of crack of $0.01672 + 0.624 = 0.64$ in. With a 42-in. diameter mud drum the total crack area is $42 \times 0.64 = 26.9$ sq. in., or 0.187 sq. ft.

Assume a draft gage reading, h, of one inch of water as the maximum pressure causing flow. The theoretical air velocity, V, with air at 70 deg. F., is 4011 times the square root of h or 4011 ft. per min. The theoretical discharge of air through the crack will be $4011 \times 0.187 = 750$ cu. ft. per min. Coefficients for flow through cracks of this sort have not been determined. From a consideration of the irregular shape and rough surface of the crack, a coefficient of discharge of 0.2 seems a reasonable assumption so the infiltration of air would then be $0.2 \times 750 = 150$ cu. ft. per min. At the assumed 70 deg. F., this is equivalent to 11.25 lb. of air per min.

With 600 deg. F. assumed as the maximum temperature of the gases leaving the boiler setting, the heat loss due to infiltration around one end of the mud drum is $11.25 \times 0.24 \times (600\text{-}70) = 1430$ B.t.u. per min. If both ends of the drum are exposed, the total leakage loss is 2860 B.t.u. per min.

Assuming an average delivered boiler horsepower of 1000 at 75 per cent efficiency, the per cent loss is found to be $[(2856 \times 60 \times 0.75) \div (1000 \times 34.5 \times 970.4)] \times 100 = 0.384$ per cent.

The magnitude of this loss is comparable to the loss due to moisture in the entering air.

The method of analysis outlined may be applied to any specific boiler for the actual conditions of operation. Assuming 70 deg. F. as the temperature of the entering air and a discharge coefficient of 0.2, the per cent loss due to infiltration around both ends of a mud drum may be estimated by use of the following equation:

$$\text{Per cent loss} = \frac{C \times D \times E \times (t_g - 70)\sqrt{h}}{2783 \times (\text{boiler hp.})}$$

C = Maximum crack width, inches.
D = Diameter of drum, inches.
t_g = Temperature of exit gases, deg. F.
h = Draft gage reading, inches of water.
E = Boiler efficiency, per cent.

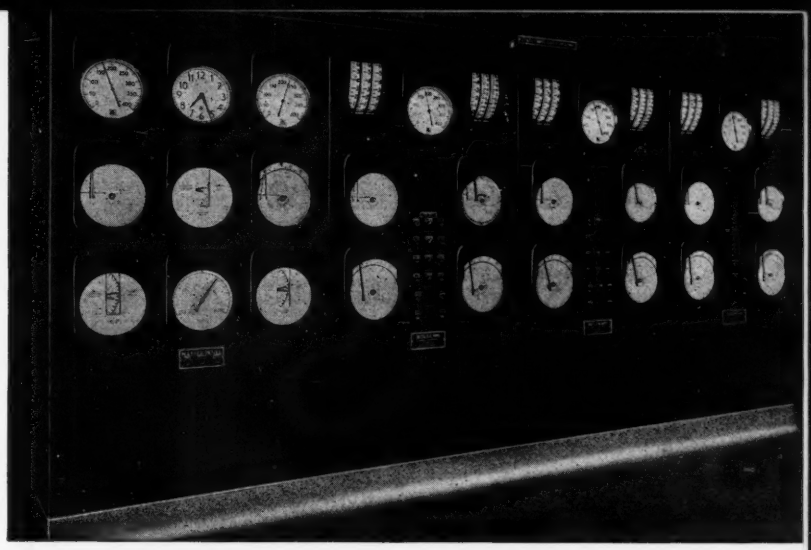
Accident Report

ACCORDING TO reports from the National Safety Council, reductions in both accident frequency and accident severity were made in the public utilities in 1935, in comparison with records for 1934. These reports have been assembled from 559 organizations whose employees worked 541,415,000 man-hours. The 1935 average frequency rate of 10.20 (the number of disabling injuries per million man-hours of exposure) is 5 per cent below the rate for 1934, and the corresponding average accident severity rate of 1.91 (the number of days lost per thousand man-hours of exposure is 1 per cent below the 1934 rate. The frequency of disabling injuries has decreased 79 per cent since 1926 which exceeds the average reduction of 61 per cent for all industries. In severity the improvement is 66 per cent, which is also considerably larger than the average reduction of 43 per cent for all industries.

*Assistant Professor of Mechanical Engineering, University of Illinois.

Combustion Control

Part XVIII. The calibrated control of the Carrick Engineering Co.



ENGINEERING AND ECONOMIC requirements of boiler plants vary greatly and to cover the entire range the Carrick Engineering Co. has developed a variety of control equipment which may be grouped roughly into three systems. First, a draft control for use with continuous or intermittently operated systems for heating plants (Part II, Page 668, December, 1935); second, positioning systems intended primarily for small and medium sized boilers where a rugged low first-cost control is desired (Part IX, Page 574, September, 1935); third, the calibrated control described below and intended for any size or pressure boilers where a complete control system is desired.

This latter system maintains steam pressure by regulating the heat release in accordance with the load on the boiler, and, at the same time, holds desired combustion conditions by supplying metered quantities of air and fuel properly mixed in the required proportion to each other. It consists essentially of four elements: a master control; an air flow control; a fuel feed control; and a furnace draft control. The general scheme of operation is as follows: variations in steam header pressure are transmitted through the master control to the air flow control and to the fuel feed control.

To meet other plant conditions an optional scheme of operation in which the fuel feed control receives its adjusting impulses from the varying air flow differential (the same as the air flow control), instead of directly from the master control is available. The furnace draft control is not connected electrically or mechanically to the other elements of the control system, but operates in harmony with them to maintain a constant pre-determined over-fire draft.

Units of the Control System

The different units of this control system have been designed to be housed in standard instrument cases as used for combustion meters, flow meters, pressure and temperature instruments. This facilitates the grouping of control and instruments on a centrally located panel and places before the operator the essential indications and records as well as the selector switches and push buttons which make manual operation optional. The following paragraphs describe the details of construction and operation of the different units which make up the complete control system.

Master Control

As shown in Fig. 1 the steam header pressure is piped directly to the master control which is responsive to variations in steam header pressure and transmits impulses to the air flow control and the fuel feed control. The master control, Fig. 2, consists of a compensated bellows type pressure-measuring element; a set of magnetically operated, fully enclosed, non-tilting mercury switches; an electric operator; means for manual adjustment, and provision for remote manual operation.

Operation is as follows: variations in steam header pressure act on the metallic bellows acting against the spring-loaded beam causing the beam to move up or down as the header pressure varies from the pre-determined desired normal value (types of pressure measuring elements other than the bellows type mentioned are sometimes used for particular ranges and conditions). The movement of the beam makes or breaks contact in one of the mercury switches, causing the electric operator to move. The movement of the electric operator adjusts the cam in the air flow control and the cam in the fuel feed control so that both controls operate in harmony with each other.

At the same time, compensation is provided by the movement of the electric operator which is linked to the mercury switches in the master control and causes them to move away from the magnet, breaking the contact so that no further action takes place until the steam header pressure again varies from the desired normal value. In multiple boiler installations the control system for all boilers operates from a common master control so that the entire plant will operate in harmony.

Adjustments

To meet varying operating conditions the adjustment of the setting of the spring-loaded beam, which determines the normal pressure to be maintained, may be changed at any time by the operator while the control is in operation by simply unlocking the case and turning a small hand wheel. Other adjustments are provided for sensitivity and speed of response. Re-

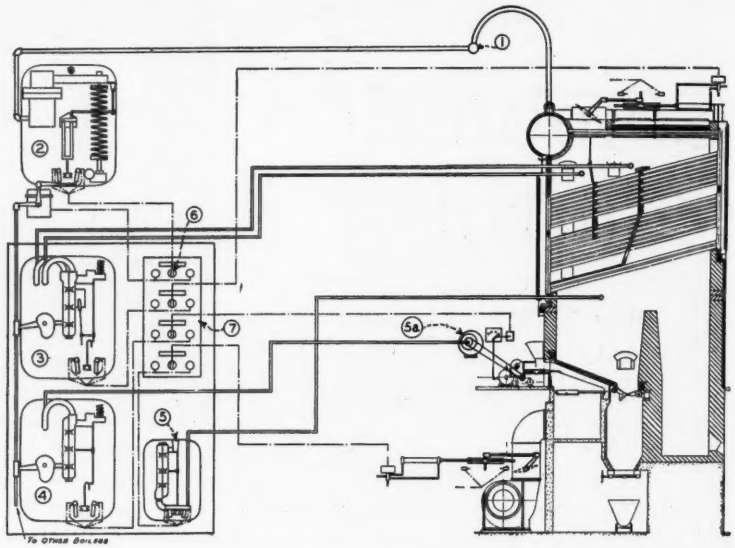


Fig. 1. Diagrammatic arrangement of the Carrick Calibrated control to a number of underfeed stoker fired boilers. For simplicity only one boiler and boiler panel are shown

Variations in steam pressure from header 1 actuate the master 2, and these movements are transmitted to the square root cams of air flow control 3 and fuel feed control 4 on each of the other boilers to bring the heat release in agreement with steam demands. Furnace pressure is maintained constant by draft control 5. Fuel flow is measured by the suction of a blower tachometer 5a, and air flow by the draft loss across the boiler.

In the above arrangement the air flow controller operates the outlet damper, the fuel controller the stoker speed and the draft controller the forced draft damper. The two dampers are shown with a solenoid operated four-way valve used in conjunction with hydraulic cylinders. The limit switches, shown but not used above, are for use in connection with a variable speed motor driven fan and would automatically increase or decrease the fan speed when the damper reaches an extreme position.

For simplicity the operating instruments which would ordinarily be installed on the panels with the controls have been omitted.

Manual or base load control of all boilers from the master panel is possible from switch and push button 6 and push button operation of any particular control is possible through panel 7.

mote push button operation and direct emergency manual operation are explained in another paragraph.

Air Flow Control

The air flow control adjusts the rate of air flow in accordance with the load being carried on the boiler and in the proper ratio and mixture to the rate of fuel feed. This unit consists of a differential pressure-measuring element: a calibrated and machined cam for receiving the impulses from the master control; provision for manual adjustment of the rate of air flow; a red and a black indicating pointer to indicate the loading on the boiler; a set of fully-enclosed, magnetically-operated, non-tilting mercury switches; push button station for remote manual operation and provision for direct emergency operation; an electric or hydraulic power unit for damper or fan speed regulation.

Operation is as follows: impulses from the master control are transmitted to a cam in the air flow control, adjusting the control for a pre-determined rate of air flow for that particular load on the boiler. Adjustment of this cam moves a magnet, making or breaking contact in one of the mercury switches to start, stop, or reverse the operation of the electric or hydraulic power unit. The power unit may be connected to an outlet damper, an inlet damper, a secondary air damper, a fan speed control, or a combination of any of the above dampers and the fan speed control.

Differential draft connections are made from two points in the boiler, as shown in Fig. 1, to each side of the differential pressure-measuring element. Variations in air flow from the desired rate cause the differential pressure-measuring element in the air flow control to move the magnet and make or break contact in one of the mercury switches to start, stop, or reverse the operation of the electric or hydraulic power unit. When the damper movement or fan speed adjustment brings the differential pressure to the required value no further change takes place unless another adjustment is transmitted from the master control, or, unless a change in combustion conditions causes a variation of the differential pressure.

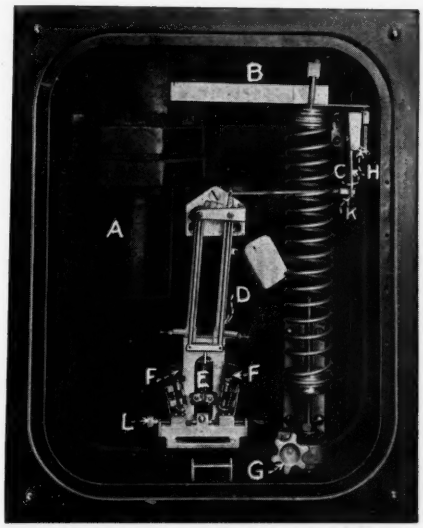
Manual adjustment of the air flow control may be made while the control is in operation by unlocking the case door and turning a small knob. On a multiple boiler installation where it is desired to favor a particular boiler or to have one of the boilers carry more than its proportion of the load this can be done by using the knob adjustments to shift the cam positions and set the air flow control of each boiler for the desired rating. The position of the red pointer in relation to the black pointer shows whether the particular boiler is set to carry more or less than its normal share of the load. Since the cams of the air flow control and the fuel feed control are linked the adjustment of the loading of boilers as explained above does not disturb the air-fuel ratio. All air-fuel ratio adjustments are made on the fuel feed control. Manual push button operation of the air flow control and direct manual emergency operation are explained in another paragraph.

Fuel Feed Control

The fuel feed control adjusts the rate of fuel feed in accordance with the load being carried on the boiler and in the proper ratio and mixture to the rate of air flow. Detailed design of the individual control will depend on the kind of fuel and the fuel-burning equipment being used. Described below is a typical fuel feed control for a chain-grate or under-feed stoker, a pulverizer with variable speed fuel feed table, or, for use with any other fuel-burning equipment where the rate of fuel feed is regulated through the use of a variable speed motor, steam engine or turbine, or a variable speed transmission.

The control consists of a negative pressure-measuring element, a set of mercury switches, a calibrated cam for receiving impulses from the master control, provision for manual adjustment of the fuel feed, push button stations for remote manual operation, provision for direct manual emergency operation, and an electric or hydraulic power unit. Operation is as follows: impulses from the master control are transmitted to the calibrated cam in the fuel feed control. The adjustment of this cam makes or breaks contact in

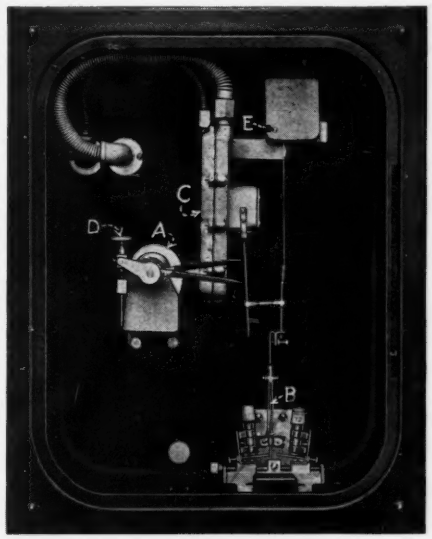
Fig. 2. Details and arrangement of the Master Control



Steam pressure acting under a bellows in case A moves spring loaded beam B and through bell crank C and pantograph D moves magnets E to close one or the other of the mercury switches F and energize a motor drive or operator in back of the case. This Motor drive is connected to the cams of the fuel control and air flow control (as shown diagrammatically by Fig. 1) and also to a compensating pantograph directly back of pantograph D.

Four adjustments are provided. Handwheel G changes the tension in the loading spring and thus controls the normal steam pressure. Changing the effective length of the bell crank F by adjustments H or K or, the distance separating the switches D by adjustment L, changes the sensitivity of the control, that is the movement of the beam necessary for full travel of the control. There is also a speed adjustment on the motor which determines the time interval of the various operations.

Fig. 3. Details and arrangement of the Air Flow Control



Movement of the cam A, through a mechanical connection from the master (shown diagrammatically by Fig. 1) moves the magnets B to open or close one of the mercury switches. Closing one of these circuits energizes a solenoid valve to change the air flow through the boiler, and this pressure differential acting through the differential gage C, is sufficient to break the electrical circuit and bring the magnets B back to mid-position. Gage C is pivoted around E and is held against the cam by a spring.

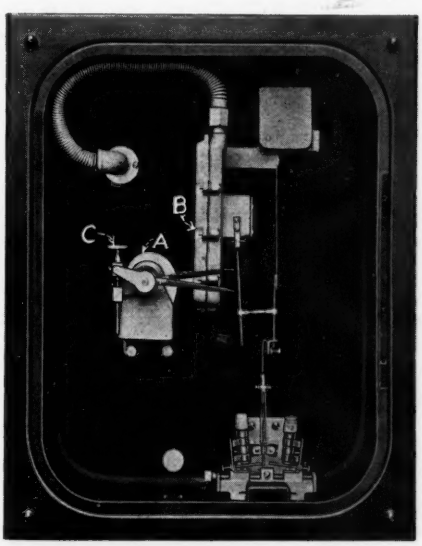
By means of thumbscrew D, the position of the cam may be changed relative to the position of the master to change or to limit the boiler load. This adjustment is of service on multiple boiler installations where it is desired to favor a particular boiler or have one of them carry more than its proportion of the load. The positions of the two pointers, one red and the other black, shows whether the boiler is carrying more or less than its normal share at any time.

one of the mercury switches, starting or stopping, or reversing the electric or hydraulic power unit. The movement of the power unit adjusts the rate of fuel feed by movement of the motor rheostat, steam engine or turbine control valve or governor, or the lever of a variable speed transmission.

A tachometer blower is connected (either by chain and sprockets or by flexible coupling) to a variable speed shaft of the fuel feeding mechanism, the speed of the shaft being taken as an indication of the rate of fuel feed. The negative pressure of the blower is connected to the negative pressure-measuring element in the fuel feed control and variations in the shaft speed will cause a consequent variation in this negative pressure. The diaphragm in the negative pressure-measuring element is attached to the switch magnet and variations in this pressure cause a movement of this diaphragm, making or breaking contact in one of the mercury switches to start, stop, or reverse the electric operator which adjusts the rate of speed of the fuel feeding mechanism.

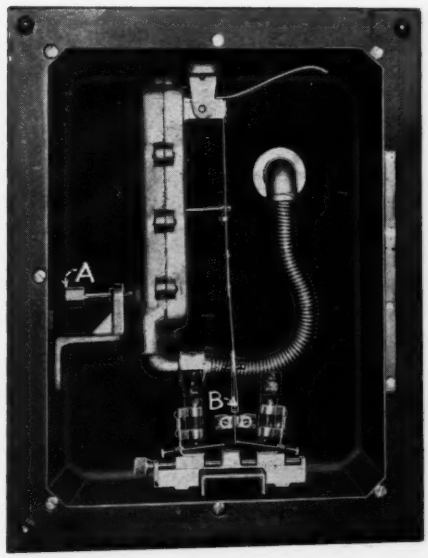
When the fuel feeding mechanism is operating at the rate required for the particular steam load, the negative pressure built up by the tachometer blower acts on the pressure-measuring unit to move the magnet and break the contact in the mercury switch, thus holding the fuel feed at the correct rate. No further change takes place unless a variation in steam header pressure causes the master control to change the position of the cam in the fuel feed control, or, if for any

Fig. 4. Details and arrangement of the Fuel Feed Control



Cam A of this control is moved, in conjunction with a similar cam on the air flow control. Closing the mercury switches increases or decreases the fuel feed by changing the speed of the stoker drive. This change in speed changes the pressure at the suction of a blower tachometer, and the changing pressure acting on the draft gage B is effective in breaking the electrical circuit when the desired fuel feed is reached. Thumbscrew C changes the air-fuel ratio. This does not change the adjustment between the master and the air flow control.

Fig. 5. Details and arrangement of the Furnace Draft Control



Action of the control is self-evident. A draft connection is made at the desired point in the furnace and by means of adjustment A the instrument set to maintain the desired pressure over fire draft. Any deviation from this value moves the magnets B so as to close one or the other of the mercury switches. Closing the switch energizes a solenoid valve to open or close the damper in the forced draft fan duct; in some cases, the speed of the fan may be controlled directly, or, a combination of fan speed and damper control may be utilized.

reason, the speed of the fuel-burning equipment should vary.

Air-fuel ratio adjustments are made in the fuel feed control by unlocking the case and turning a knurled knob. This moves the cam in the fuel feed control to a different relative position to the cam in the air flow control as indicated by the position of the red and black pointers. When the ratio of fuel to air is decreased the red pointer is below the black pointer. When the ratio of fuel to air is being increased it is above the black pointer. The relation between the master control and the air flow control is not disturbed by the adjustment of the cam in the fuel feed control. Remote manual push button operation and direct manual emergency operation are described in another paragraph.

For liquid or gaseous fuels a suitable metering type of fuel feed control is provided and the rate of fuel feed is controlled through the use of a power-operated valve.

Furnace Draft Control

Furnace draft control maintains the overfire draft at the required value. Although it is not mechanically or electrically connected to the other control elements it is obvious that as the master control, air flow, and fuel feed controls act together to change combustion conditions the furnace draft control will work in harmony with them and will automatically hold the combustion chamber draft constant whenever conditions are changed by the other units of the control. The furnace draft control consists of a draft-measuring element; a set of mercury switches; an electric or hydraulic power unit; provision for manual adjustment; and provision for remote manual operation.

Operation is as follows: a connection is made between the draft-measuring unit and a point in the combustion chamber in the boiler furnace. As the combustion chamber draft varies from the required value, the diaphragm in the draft-measuring unit moves the magnets, making or breaking contact in one of the two mercury switches to start, stop, or reverse the operation of the electric or hydraulic power unit. The power unit is connected to the outlet or inlet damper or fan speed regulator, or a combination of a damper and fan speed regulation. When the movement of the power unit has changed conditions to bring the draft to the desired value, the diaphragm in the draft-measuring unit promptly positions the magnets in the off position and no further action will take place until the draft again varies. A simple set-screw adjustment inside the case makes it possible to change the draft setting. Manual push button operation of the draft damper or fan speed regulator and direct manual emergency operation is explained in another paragraph.

CO_2 Compensation

Variations in the quality of solid fuels, liquid fuels, or gaseous fuels sometimes call for an automatic correction on the basis of the percentage of CO_2 in the flue gas. Provision for such compensation is made in this system and it operates as follows: the result of flue gas analyses is transmitted from a Hays CO_2 recorder to the fuel feed or air flow control to modify the setting and to compensate for variations in fuel quality. This corrective adjustment operates over a sufficiently wide range to compensate for variations in fuel quality to be encountered. The oxygen content in the flue gas as measured by a Hays O_2 recorder may also be employed to correct the air-fuel ratio.

Remote Push Button and Direct Emergency Operation

For the convenience of the operator in handling the usual plant conditions such as soot blowing, cleaning of fires, removal of ashes, preparation for predictable sudden load changes, cutting boilers on and off the line, distribution of load between the boilers, etc., provision is made for remote manual operation of any or all of the control elements. A selector switch and two push buttons is included for each unit of the control. The operator may move selector switches from the automatic to the manual position and then, by means of push buttons, may control the operation of any or all of the elements of the control system. By selecting manual operation for the master control and allowing the other elements of the control to remain on automatic operation, the operator may control the entire system through the movement of the master control. If manual operation is selected for all of the elements of the control and any one of them manually operated, the remaining controls will remain fixed until the selector switches are again turned to the automatic position. The individual controls will then immediately and automatically operate to bring the combustion conditions to correct ratios.

In multiple boiler installations manual operation of the control on one particular boiler may be accomplished by a hand-wheel arrangement fitted with a clutch. When it is desired to transfer from automatic to manual operation, the operator, by means of the clutch arrangement, disengages the connection from the electric operator of the master control, and, by turning the hand-wheel, simultaneously adjusts the cams in the air-flow and fuel-feed controls of that particular boiler.

By means of the selector switches and push buttons, the operator can make suitable adjustment on any part of the control. The hand operation of valves in hydraulic power units and mechanical disconnects on electric power units makes it possible to operate a plant manually in case of power failure or other emergency.

For positioning dampers, operating fan speed regulators, stoker speed regulators, and other uses where power is required in these control systems special electric and hydraulic power units are provided. A variety of standard motors and gear reductions are available for the electric power unit, but the usual equipment is a reversible shaded pole motor with built-in, oil-immersed reduction gears, speed adjusters and limit switches. The two types in most general use develop respectively 18 and 62½ ft. lb. Hydraulic power cylinders in all sizes from 1 to 6 in. in diameter, operated with oil, or water under pressure, are available and adaptable to all control requirements. Solenoid-operated pilot valves receiving impulses from the various units of the system cause the pistons in the power cylinders to respond to the controls.

Oil Burners *for* Power Boilers

Success in the Use of Fuel Oil for Steam Generation Depends in Large Measure Upon the Selection of the Proper Type of Oil Burner

By James O. G. Gibbons*

OIL BURNERS usually employed in industrial oil burning installations, may be classified into three types: the mechanical pressure, generally called mechanical burners, the steam atomizing burners, and the spinning cup burners.

In the mechanical type of burner, atomization is carried out by forcing the oil under high pressure through a special tip having a small orifice from which it emerges as a hollow cone of finely atomized particles. The oil is pumped to the burner at a high temperature, which depends upon the viscosity of the oil, and the pressure is generally above 200 lb. per sq. in. The capacity varies as the square root of the pressure, so a reduction from 200 lb. to 50 lb. per sq. in. will cut the capacity in half, but 50 lb. pressure gives very coarse atomization, therefore it is difficult to operate most makes of mechanical burners through a wide range.

As a rule, it is necessary to change the tips for low loads, but unfortunately it is difficult to get a tip with a sufficiently small orifice which will not give trouble through blocking.

One make of burner is on the market, for which the claim is made that these difficulties are overcome, but as a rule mechanical burners do not lend themselves readily to wide range operation.

This type of burner is not uncommonly operated under forced draft, and some manufacturers furnish special burner and blower units, but as all the air is introduced around the burner itself, it is comparatively easy to supply the air under pressure from an independent source.

Owing to the fact that the flame is cone shaped it is not possible to operate satisfactorily this type of burner under low set boilers, as combustion must be complete before the flame touches the comparatively cool elements of the boiler, otherwise it will be chilled below ignition temperature.

With the mechanical burner, it is necessary to change the tips at relatively frequent intervals so that the orifices can be cleaned, and they should always be withdrawn when shut down, otherwise the heat of the furnace will carbonize the oil and it will be baked into the orifice. This is not a serious operation but it is one which must be done if satisfactory operation is to be insured.

Figure 1 illustrates the general principle of the mechanical burner. It is not intended to describe any particular make, but the drawing is typical of most of them. It will be seen that air is introduced around the cone of atomized oil, which presents an extended surface to the air. The air volume is controlled by shutters which enable the flow to be closely regulated.

Steam Atomizing Burner

The flat flame external mixing steam atomizing burner is shown in Fig. 2 which is representative of this type, except that it shows the oil in the burner steam jacketed, and an integral steam separator is embodied in the design.

Dry steam is extremely desirable to the best operation of steam atomizing burners, and anything that will insure this is advantageous.

The oil is supplied only under sufficient pressure to insure a proper feed to the burner, generally about 15 lb. on the supply mains, which reduces the cost of the installation as high pressure fittings are not

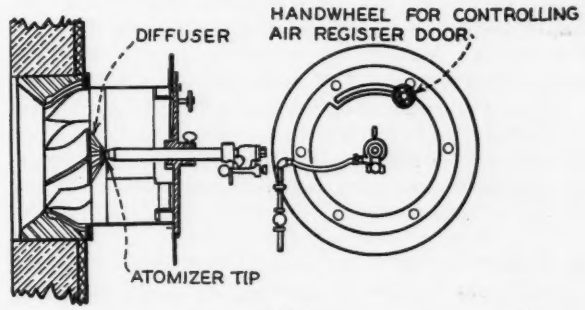


FIG. 1

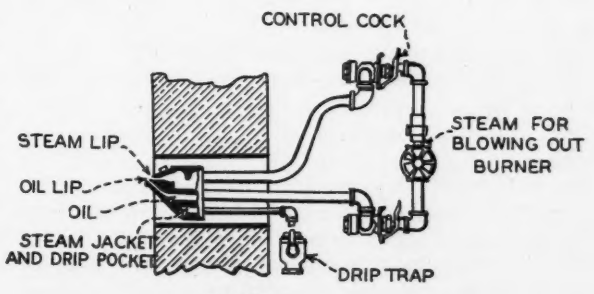


FIG. 2

Fig. 1. Mechanical type oil burner

Fig. 2. Steam atomizing burner of the externally mixing type

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necessary, and it also keeps the power required for pumping the oil down to a minimum.

The shape of the flame is controlled by forming the steam and oil lips, and a flame of any spread can be produced. As the flame is flat, and its shape closely controlled, it is possible to operate successfully under low set boilers, especially if proper consideration be given to the correct design of the furnace.

With this burner, only a small amount of air is introduced around the burner itself, the greater part being introduced through a checker work floor under the flat flame.

Owing to the fact that flat flame burners can be installed only a few inches above the furnace floor, very satisfactory installations can generally be made under water tube boilers by firing them from the rear instead of from the front, thus insuring a long flame travel in a comparatively short furnace. This method of installation is also suitable for fire box type of boilers.

The steam required for atomizing and pumping should not exceed two per cent of the boiler output, and the exhaust steam from the pump will generally take care of the oil heaters.

These burners can, if desired, be operated by compressed air instead of steam, but there is little doubt that the refrigerating effect of expanding air tends to delay ignition, and high temperature steam is to be preferred.

Burners of the type illustrated have been successfully operated with steam as low as 10 lb. gage at the boiler, and when the steam is throttled by the regulating cocks for low loads, the pressure is never high in the burner, but the greater heat content of steam at a higher boiler pressure, which is not lost in throttling, is generally advantageous.

One advantage of this type of burner is that the oil outlet orifice is of considerable area, and it is practically impossible to clog it, so that oil strainers are not required. It can generally be said that anything that will go through the pumps will go through the burner, and anything that is burnable will be burned.

Figure 3 illustrates an internal mixing type of steam atomizing burner in which the steam and oil come together inside the burner, whereas with the external mixing type, the steam and oil come together as they leave the burner.

Atomizing Accomplished by Centrifugal Force

The rotary cup type of burner depends upon the centrifugal force generated by a spinning cup, to atomize the oil, which is fed to the cup through a hollow shaft.

In one type of spinning cup burner, the oil is fed to the inside of the cup through a shaft which not only carries the cup, but also the rotor of an air turbine. The air which is supplied by an independent fan or blower, drives the shaft and also serves as primary air for combustion, the secondary air being taken through a register around the burner in very much the same way as that described for mechanical burners. The fan and oil pump for this type of burner, are mounted together with an electric motor on an independent base.

The rotary type burner shown in Fig. 4 is similar in operation to that described above, except that the cup, fan, oil pump, and electric motor are mounted together on the same hollow shaft forming an integral unit.

The burner illustrated also carries a gas pilot which permits operation under full automatic control, that is, the oil flame can be lighted and extinguished automatically, as well as by hand control. The installation of the gas pilot is, however, optional and is not necessary where full automatic control is not desired. Electric ignition may be used instead of gas if preferred.

This type of burner will generally burn No. 5 oil without preheating and No. 6 oil when heated to about 150 deg. F., but it must be remembered that the standard specifications permit a wide range of viscosities even with No. 5 oil, and a burner installed for No. 6 oil will generally be expected to burn oil of any viscosity, and the higher the viscosity, the higher the temperature required.

Characteristics of Different Burners

It is not intended to advocate the installation of any particular type of burner, they all have their special applications, and full information regarding the burner under consideration should be obtained from the makers. There are, however, several points which should be kept in mind when choosing a burner for any particular service, and the major characteristics of the different types may be summarized as follows:

Steam atomizing burners cannot be started up unless steam or compressed air is available, but as a rule, a few pounds only are required to enable the burner to be started and the boiler pressure built up. This, however, is a point which should be taken up with the makers of the burner.

This type of burner generally has free oil openings and it should seldom be necessary to withdraw it for cleaning, especially if a steam connection is provided for blowing it out while in place. Moreover it should not block even if there are no strainers in the oil line. The burner lends itself to wide ranges of operation as the oil supply can be cut down to a minimum and the steam will pick it up and atomize it.

The claim is often made that steam atomizing burners take an excessive amount of steam for atomization. It is undoubtedly true that a great deal of steam may be wasted, but with the right kind of burner and intelligent handling, the amount of steam should be quite small. The steam required for heating will be less than that for the mechanical type and as a rule exhaust steam which might otherwise be wasted can be used almost entirely.

As previously pointed out, a flat flame burner can be operated with low head room, and this is often a distinct advantage, moreover the flame can be made to conform to almost any width of spread so that it can be correctly adjusted to the shape of the furnace. Of course other types of burners can be made to give a wide spread but the flame is round and the available height limits the diameter of the cone, so it is often necessary to install a larger number of burners than would otherwise be necessary, to cover the width of the furnace.

The mechanical burner lends itself readily to forced draft operation but when the load is of a fluctuating

nature, and especially when it falls very low at times, the difficulty of taking care of these conditions in a satisfactory manner should be given careful consideration.

Power

The amount of oil to be pumped and the pressure required for atomizing, being known, it is comparatively easy to figure with a fair degree of accuracy, the power required to operate mechanical burners, and if this is done it will be found that the amount of power is comparatively low, especially in large installations where the pump and line losses can be kept to a minimum.

A little more steam will be required for heating the oil than that required with other types of burners, but

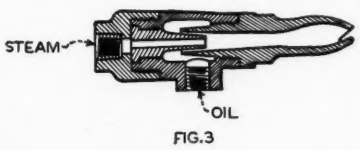


FIG.3

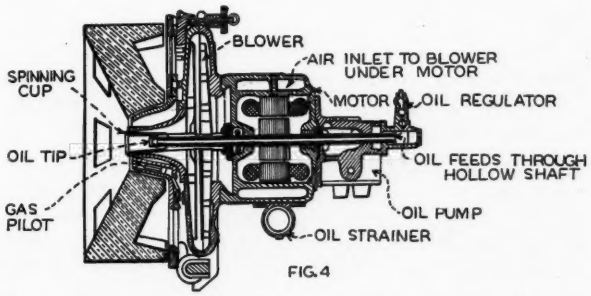


FIG.4

Fig. 3. Steam atomizing burner of the internally mixing type
Fig. 4. Oil burner employing motor driven spinning cup

this again can be accurately figured, and if desired, the heating can be done in two stages, the first stage being operated with exhaust steam.

It is necessary to use strainers with this type of burner, and there is considerable danger of blockage of the orifices if they are not kept clean.

Hot Oil

The spinning cup type has the advantage that it can, in some cases be assembled as a self-contained unit. The question of satisfactory atomization should, however, be given careful consideration. It should also be kept in mind that where the pump is assembled as part of the burner unit, the oil will be under a negative, or suction pressure until it reaches the burner, which means that where, as in the case of high viscosity oil, the oil has to be heated, the hot oil is on the suction side of the pump which is something to be avoided if it is desired to keep out of trouble. No matter what type of burner is used, hot oil should be under positive pressure and every precaution should be taken to avoid the accumulation of gas in the system.

As a rule, this type of burner is operated by an electric motor, either directly, or by air furnished by a motor driven fan, and it is therefore independent of the available steam pressure. On the other hand, a burner of the steam atomizing type, can be operated with air, and mechanical burners can be operated with motor driven pumps.

There are several makes of burners on the market which will handle powdered coal, oil, and in some cases gas, in the same burner, and under special circumstances such burners may be given consideration, their general operating characteristics are, however, the same as those of the straight oil burner when they are using oil as fuel.

U. S. Oil Reserves Good for Only 15 Years

At the present rate of consumption the coal reserves of the United States should last several thousand years, whereas the known oil reserves would last only 15 yr., W. A. Selvig, Bureau of Mines, Department of the Interior told the Purchasing Agents' Association meeting in Hamilton, Ontario, Canada, recently.

About one per cent of the original coal reserves of the United States have been consumed, leaving an estimated three and one-half trillion tons still in the earth, and making this country the repository for about half of the world's supply. It must be said, however, the greater reserves consist of low rank bituminous coal, subbituminous coal, and lignite, while reserves of the higher rank coals are relatively small. As the bulk of coal mined consists of the high grade, high rank coals, the best naturally will be the first to be exhausted.

Oil Reserves

At the present rate of consumption of 900 million bbl. per yr., the known oil reserve in the United States will last only about 15 yr. Although new oil reserves will be discovered from time to time in the future, nevertheless, the frequency at which new fields are being found is declining and the necessity of supplementing oil with liquid fuel from coal may be required within the present generation. The proven oil reserve is less than 0.1 per cent in heating value of the coal reserves, according to a study made by the Geological Survey and the Bureau of Mines, with only 13⅓ billion barrels.

During the years of the depression there was a steady decline in the amount of coal consumed and since then the decline has continued, largely because use of coal has been displaced by oil burners for industrial and domestic heating; gasoline powered automobiles, buses, and trucks have replaced some of the coal burning railway trains; and oil burners are substituting for many of the coal propelled steamships.

A table prepared by the Bureau of Mines shows the per cent of total heating value contributed by the several mineral fuels of the United States, and shows clearly what percentage each contributes to the heat and power of the nation developed by fuels.

	1913	1923	1934
Anthracite	14.4	10.9	8.4
Bituminous coal	72.7	62.4	50.8
Total coal	67.1	74.3	59.2
Oil	9.3	21.1	30.5
Natural gas	3.6	4.6	10.3
Total mineral fuels	100.0	100.0	100.0
Water power	3.4	4.9	10.2

Power *and* Steam *for* Bethlehem's New Continuous Strip Mill

Four 500 hp. stoker fired boilers and three 5000 kv-a. transformers installed

AT ITS LACKAWANNA, N. Y., plant, The Bethlehem Steel Co. has just finished the installation of a continuous hot strip mill designed to produce strip and sheet of 18 gage and heavier. In order to round out the capacity in the lighter gages, a strip mill has also been installed for the production of cold rolled (full finished) sheets, in the usual gages, up to 84 in. in width. The so-called flat-rolled products consist of plates, skelp, sheet bar, strip, sheets, and tin plate. Their production in quantity has been steadily increasing from year to year, particularly strip and sheets, until today the latter two alone account for over 30 per cent of the total finished steel commodities produced.

In general, the new 79 in. hot strip mill comprises a roughing train and finished train. The roughing train includes a 2-high scale breaker, a 4-high spreading stand, and three 4-high universal stands with vertical rolls on the entering side. The finishing train comprises a 2-high scale breaker, and six stands of 4-high rolls. Immediately following the last stand of the finishing train there is located a rotary flying shear for cutting material, hot, direct from the mill. The cold strip mill comprises: a 3-stand 4-high 75 in. tandem cold strip mill followed by a reel; one single stand 4-high 75 in. tempering mill equipped with a reel for rolling coils; one single stand 4-high 93 in. tempering mill, and one single stand 75 in. tempering mill without reels for rolling short sheet lengths. In addition, there is a single stand 2-high 54 in. skin pass mill, equipped with reel, for rolling coils.

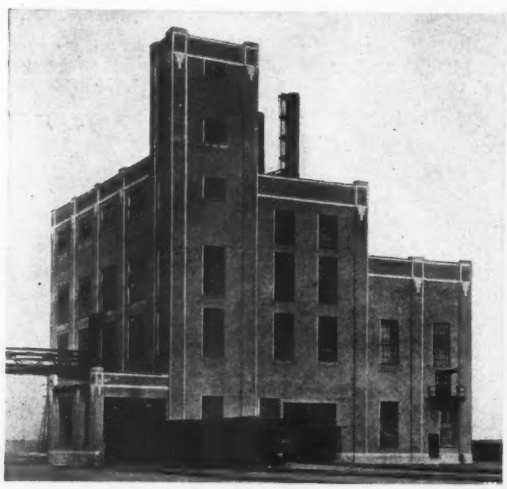


Fig. 1. The boiler house is located apart from the main buildings

Boiler House

Steam for processing and heating is supplied by a boiler house equipped with four 500 hp. boilers. Due to the distance between the new strip plant and the present steel plant, it became necessary to provide an independent steam station. The units are six-drum water-tube boilers, rated at 500 hp. each, designed to produce steam at 150 lb. pressure and 200 deg. superheat. Each boiler is capable of operating at 200 per cent rating. By-product coke breeze is used as fuel, and will be handled from cars to storage bunkers containing 24 hr. fuel supply at each conveyor and tripper, from which the fuel is fed to the boilers by traveling chain grate stokers. The working floor of the boilers is elevated 22 ft. above ground, to allow easy disposal of ashes directly into hopper cars, through power-operated water-tight ash gates.

Water-treating and softening apparatus has a rated capacity of 16,000 gal. per hr. of raw water, and provision has been made to return to the boiler plant all unit heater steam condensate from the cold mill heating system to cut down raw water consumption. Boiler feed pumps, water softening plant and two 2000 c.f.m. air compressors for general plant service are located in a lean-to directly adjacent to and forming a part of the boiler house proper. The building is of steel-frame construction, with walls entirely of brick and glass.

Electric power to operate the strip plant is delivered from Niagara Falls over a 60,000 v. high tension transmission system to a substation in the vicinity of the plant, where the voltage is stepped down in a bank of three 5000 kv-a. transformers to 6600 v. for mill consumption. From the substation the power is distributed to the hot mill motor room and the cold mill substation by an overhead transmission system. To

insure an uninterrupted supply of power to the mill motors, the main transmission system is connected with the present steel plant power lines.

Hot Mill Motor Room

Motors for driving the 12 stands of the hot mill are located in the motor room, parallel with and adjacent to the mill building. The motors are segregated in two groups, the roughing mill drives and finishing mill drives, the former being driven by alternating current motors and the latter by direct current adjustable speed motors. A 1000 hp., 375 r.p.m. motor drives No. 1 scale-breaking stand. The remaining four stands of the roughing group are each driven through

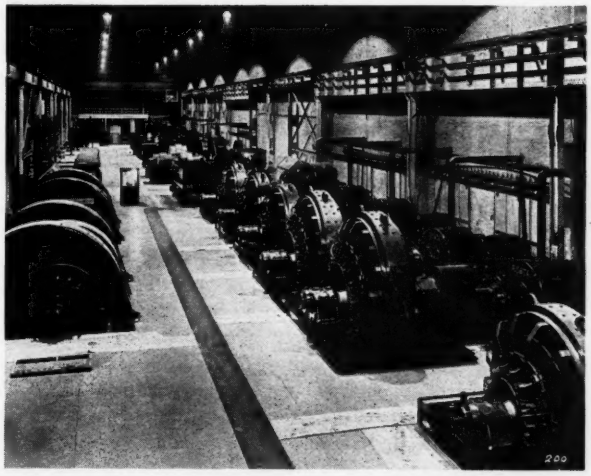


Fig. 2. Motor and generator room of the hot mill department

reduction gears by a 3000 hp. constant speed induction motor.

Number 2 scale-breaking stand at the finishing group of mills is driven by a 500 hp. d.c. adjustable speed motor, while 3500 hp. d.c. adjustable speed motors drive stands No. 5, No. 6 and No. 7. Two 4500 hp. d.c. adjustable speed motors drive stands No. 8 and No. 9, and No. 10 stand is driven by a 2500 hp. d.c. adjustable speed motor. All finishing mills, like the roughing stands, are driven through reduction gears.

Direct current power for the operation of the adjustable speed finishing mill motors is supplied by two 6000 kw., three-unit synchronous motor generator sets, each made up of two 3000 kw. 600 v. direct current generators and an 8500 hp., 6600 v., 25-cycle synchronous motor. These machines are located in the hot mill motor room.

Direct current at 250 v. for the operation of cranes and small mill table motors is supplied by two 1500 kw. motor generator sets, located conveniently on the floor of the hot mill motor room.

Motor generator sets and control panels for the intricate control and operation of the hot flying shear are also located in the motor room along with the high tension circuit breakers, control panels for the large motors, as well as the control panels for the smaller auxiliary motors.

Auxiliary alternating current power is supplied through two banks of transformers, one bank of three 1000 kv-a., 6600/440 v. and one bank of three 500 kv-a., 6600/440 v. These units supply power for motors lighting and general service.

About 900 motors, ranging in size from 0.66 to 10 hp., are provided to drive the 1700 rollers in the finishing department tables. The motors on certain tables are adjustable speed, alternating current, and are synchronized to operate the roller tables to suit the speed of the product being rolled on the mill. Where variable speed is not essential, the table rollers are equipped with constant speed alternating current motors. The table rollers are arranged so that they are driven in pairs by a single motor, or individually driven, depending upon location of the table proper.

Power for the operation of the table motors is supplied by six variable frequency motor generator sets equipped with two m.g. sets to supply the necessary dynamic braking and excitation.

Cold Mill Motors and Generators

Each of the nine 4-high cold mill stands are driven by a 1250 hp. direct current adjustable speed motor, driving the mill through a combination pinion and reduction gear. A 250 hp. direct current adjustable speed motor drives the 2-high skin pass mill. Control apparatus for the motors is located in control rooms placed in a basement directly under the motors and pinions.

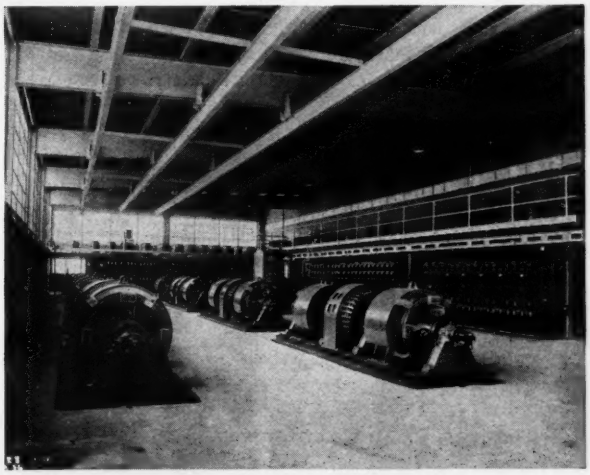


Fig. 3. Variable frequency motor generator sets

Power for the cold mill motors is supplied from three three-unit generators located in a building in close proximity to the mill stands. Power is transmitted from the generators to the several motors through a system of bus work in underground tunnels.

In the hot mill there are 1350 motors and 24 generators, giving a total of 111,000 hp. of rotating machinery. In the cold mill there are about 450 motors and 11 generators, giving a total capacity of about 49,000 hp., making a grand total of 160,000 hp. of rotating electrical apparatus for the entire strip plant.

Characteristics of Multicylinder Fuel Injection Pumps

Extensive tests show that for normal loads the variation in fuel distribution is small

ALTHOUGH it is true that the fuel-injection system provides the possibility of improved distribution control and engine operation, no data on extended tests have been available to show the actual variation in fuel quantity delivered from a multicylinder injection system over a wide range of operating conditions. The tests discussed below are part of a general investigation of fuel-injection systems conducted by the N.A.C.A. at Langley Field, Va., and reported by A. M. Rothrock and E. R. Marsh in Report No. 533. A six-cylinder commercial fuel-injection pump was adjusted to give uniform fuel distribution among the cylinders at a throttle setting of 0.00038 lb. per injection and a pump speed of 750 r.p.m. The throttle setting and pump speed were then varied through the operating range to determine the uniformity of distribution and regularity of injection.

The pump was of the constant stroke type, the throttle control being obtained by rotating the pump plunger and so controlling the duration of injection by the relationship between the helix on the plunger to the ports in the sleeve. This pump was particularly well suited for these tests because of its extensive service. Injection valves investigated were of the automatic spring-loaded type. The injection valve that was used most extensively had a single 0.020-in.

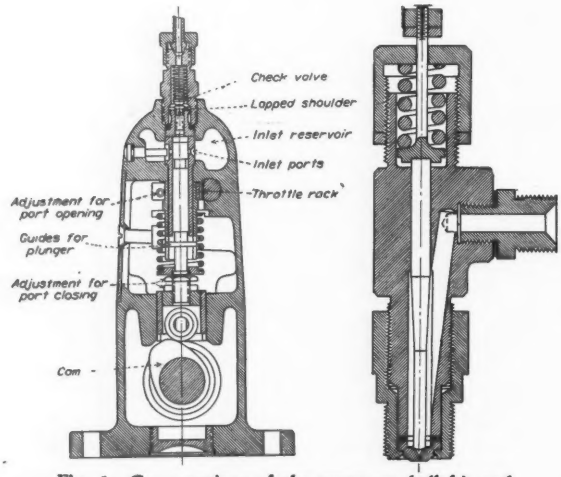


Fig. 1. Cross sections of the pump used (left) and of the injection valve (right)

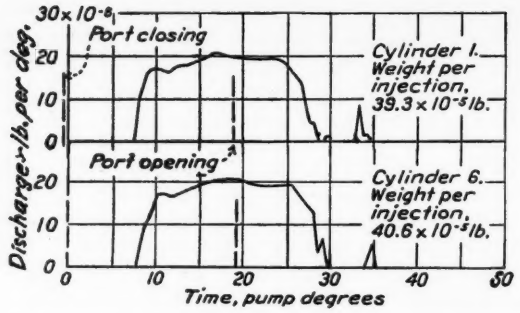


Fig. 2. Comparison of the fuel discharge from two of the six cylinders, pump speed 750 r.p.m., 0.020 in. orifice, valve opening pressure (v.o.p.) 3600 lb. per sq. in.

orifice. Two injection-valve springs, designated 1 and 2, with spring scales of 780 and 3480 lb. per in., respectively, were tested.

Diesel fuel employed had a viscosity of 0.102 poise at 20 deg. C. and a specific gravity of 0.85. All the fuel was centrifuged before being placed in the fuel tank. Gasoline was not tested because of the fire hazard but it has been shown that the operation of the injection system would be the same for either gasoline or Diesel fuel.

Rates of discharge from all six cylinders were taken and cylinders 1 and 6 are shown by Fig. 2. The total variation of the fuel quantity is $\pm$ 1.5 per cent and the variation in injection timing is less than $\pm$ 0.5 pump shaft degree. The shape of the curves is also quite similar, showing the variation in the average rates of discharge to be negligible.

Stem-lift records for two of the six pump cylinders for several pump conditions are shown in Fig. 3. The similarity of the records, even to the small oscillations caused by the deflection of the different parts of the recording system, is noteworthy. At low speed and low throttle settings the variations in the records become proportionally greater and the result is shown by the percentage increase in the variation between the different pump cylinders. The total variation in distribution was $\pm$ 2 per cent considering all the cylinders and $\pm$ 1 per cent considering cylinders 2, 3, 4, and 5, which had the least service.

In order to determine the effect of the injection-valve seat on the average rates of discharge, an injection valve was tested that had seen considerable service as a pressure-relief valve on another injection system. The rates of discharge, Fig. 4, were changed to some extent by polishing the valve seat. An even greater change was obtained, however, by allowing the polished seat to be run in. Three runs made under this last condition showed similar rates except for the initial period of injection. The differences in the initial rates of injection before and after the injection valve was run in are caused by the poor seal at the seat when the valve was first tested. This faulty seating caused the residual pressure between injections to fall below its full value causing the initial rates of discharge to be decreased. Even with the leaking seat, the total quantity of fuel injected did not show much variation.

Tests having shown that a multicylinder pump could be adjusted for one throttle setting and speed

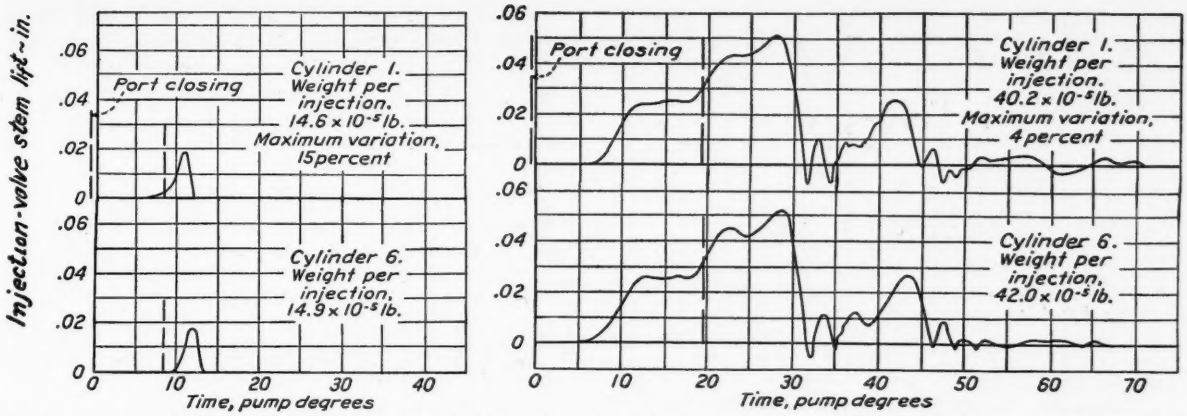


Fig. 3. Stem lift diagrams. Left 250 r.p.m. one-ninth throttle setting, injection spring 1, v.o.p. 2500 lb. Right, 1000 r.p.m., two-thirds throttle settings, injection spring 2, v.o.p. 2500 lb. Check valve with lapped shoulder in both cases

to give excellent distribution, tests were made to determine what the distribution would be over a number of different conditions of throttle settings and pump speeds. With each valve the distribution was best at a speed of 750 r.p.m. and with a fuel quantity of 0.0004 lb. per injection, the conditions for which the pump had been adjusted. The percentage variation was greatest at low speeds and low throttle settings. At speeds of 500 r.p.m., or greater, and throttle settings of 50 per cent pump capacity, or greater, the variation was never more than $\pm$ 3 per cent. The tests show that it is difficult to adjust the pump for correct distribution under one condition and have the adjustment hold under all conditions. The differences in fuel quantities injected are caused by the variations in the pump dimensions and in the variations in the leakage between the plunger and the sleeve. The results of the last mentioned cause should be inappreciable except at the light loads and the low speeds.

Changing the injection-valve opening pressure has little effect on the distribution. The greatest numerical variation in distribution occurs at full throttle and low speed, indicating that leakage plays an important part under these conditions. With cylinder 6 the leakage at the low speed and high throttle setting increased considerably as the injection-valve opening pressure increased.

It should also be mentioned that at the setting of 0.0004 lb. per injection at which the leakage was the least the area of lapped surface sealing the fuel under high pressure from the intake manifold was a maximum. At higher and lower throttle settings one edge of the port is closer to the edge of the helix on the plunger and greater leakage will therefore result.

Valve-stem lift records are presented to show the degree of regularity of the injections under different conditions of operation. When a single curve is shown it signifies that under that condition the stem motion, and therefore the injection cycle, repeated itself in each successive cycle. When such was not the case several different curves, the number depending on the number recorded, are presented. At the conditions for which two curves are shown, the odd cycles repeated themselves following one of the curves and the even cycles followed the other curve.

At certain pump speeds, as many as 3 or 4 regular cycles were obtained. At low pump speeds and low throttle settings, the pump injected only on every other revolution. Any injection system employing a volume of fuel under pressure between the source of that pressure and the discharge orifice must of a necessity operate with pressure waves. The magnitude of the waves may, of course, vary. As the injection-pump plunger travels upward and the port in the sleeve is closed, a pressure wave is started through the injection tube to the discharge orifice. If the initial wave front is of sufficient intensity to open the injection valve, the injection starts as soon as the wave front reaches the valve. If the wave front is not of sufficient intensity to open the injection valve, the entire wave is reflected through the injection tube.

Since, in general, an injection pump operates at an increasing rate of plunger displacement during the injection period, the intensity of the wave front continually increases. Any time that this primary wave

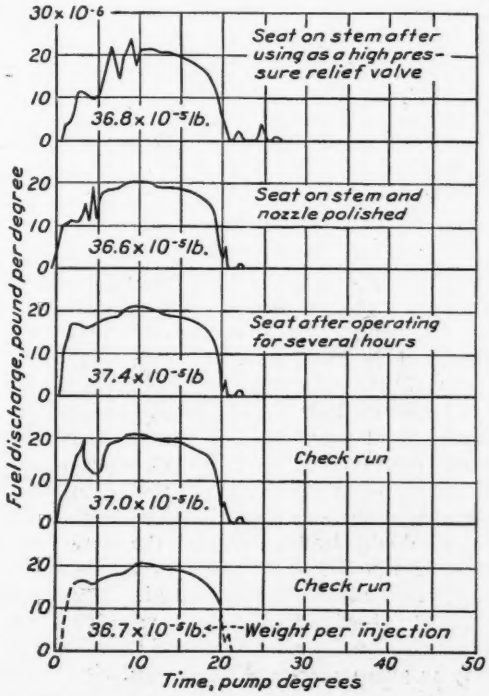

30 x 10⁻⁶
Fuel discharge, pound per degree
Seat on stem after using as a high pressure relief valve
36.8 x 10⁻⁵ lb.
Seat on stem and nozzle polished
36.6 x 10⁻⁵ lb.
Seat after operating for several hours
37.4 x 10⁻⁵ lb
Check run
37.0 x 10⁻⁵ lb.
Check run
36.7 x 10⁻⁵ lb.
Weight per injection
0 10 20 30 40 50
Time, pump degrees

Fig. 4. Effect of nozzle seat on rate of discharge, pump speed 750 r.p.m., 0.020 in. orifice, v.o.p., 3600 lb. cylinder 6

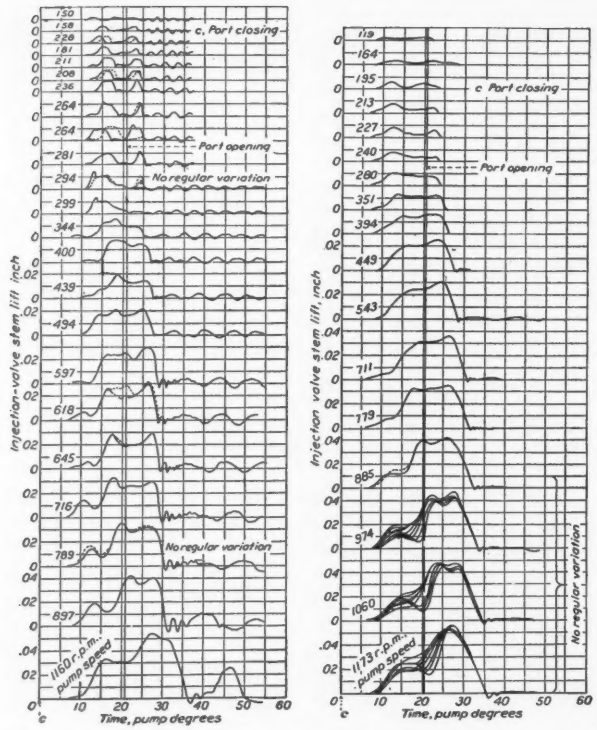


Fig. 5. Effect of pump speed on valve stem motion. Left, check valve with lapped shoulder, v.o.p., 3600 lb., injection valve 2. Right, no check valve, v.o.p. 1500 lb., injection valve spring 2

front reaches a value of sufficient intensity to open the injection valve, injection starts. The conditions, however, may be such that the injection valve is not opened until this primary valve is reenforced by a reflected wave. In this case the minimum injection lag is three times the time required for the wave to traverse the length of the injection tube. Because of this factor, neither the time lag of injection nor the minimum quantity injected is necessarily a function of the pump speed.

Figure 5 shows the injection-valve-stem lift records at different speeds. In these tests the entire speed range was slowly traversed and records were taken at the various speeds shown. With the injection pump tested, the check valve between the injection pump and the injection tube had a lapped shoulder that dropped the residual pressure in the injection tube to a value below the injection-valve closing pressure because the closing of the check valve increased the volume between the pump and the injection valve.

When the check valve was entirely removed the residual pressure became negligible, the injection was regular at the low speeds, and there was not the phenomenon of "missing" on every other revolution. With the particular pump tested, the injections at the high speeds became irregular. This irregularity was caused, no doubt, by the fact that the intake manifold of the pump was not designed to take care of the violent pressure fluctuations transmitted to the intake manifold at cut-off when the check valve was removed. Increasing the pressure of the fuel in the intake manifold of the pump decreased the irregularity.

The following conclusions are presented for the type of pump tested:

1. A multicylinder fuel-injection pump can be so constructed that even after the pump has seen considerable service the distribution between the different cylinders does not vary by more than ± 3.0 per cent for all conditions of throttle above one-half throttle setting and for all speeds that are expected to be used in practice.

2. For loads of one-tenth throttle or less the variation in distribution may be as high as ± 17 per cent of the fuel quantity being injected although, in general, the distribution should not vary more than about ± 10 per cent under this low throttle setting.

3. When the individual cylinders are so adjusted as to give good distribution, the time rate of discharge curves for all cylinders are quite similar.

4. Poor seating of the injection-valve stem results in variation in residual pressure in the injection tube and in the initial rates of discharge.

5. Irregularities in the injection from each individual cylinder will occur at low throttle settings, at low speeds, or both because of variations in the residual pressure in the injection tube.

6. The irregularities mentioned in conclusion 5 can be decreased by decreasing the injection-valve opening pressure, by maintaining the residual pressure in the injection tube close to the injection-valve opening pressure, or by eliminating the check valve between the injection pump and the injection tube.

7. If no check valve is used between the injection pump and injection tube, irregularities may occur at high pump speed unless the intake manifold of the pump is of sufficient size to dissipate quickly the energy of the fuel in the injection tube at the instant of cut-off.

8. The regularity of injection is increased by the using of a very stiff injection-valve spring or by limiting the stem lift.

9. The lapped shoulder on the pump check valve gives a more rapid drop in pressure at injection cut-off but tends to increase the irregularity of injection at low speeds.

10. The type of injection valve used, provided that the seats are in good condition, has little effect on the distribution of a multicylinder pump.

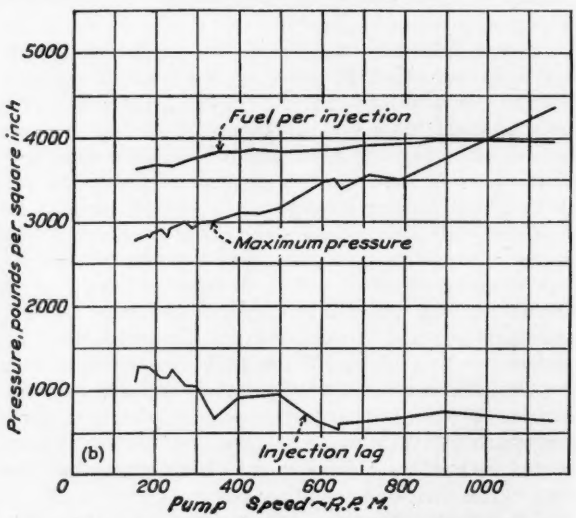


Fig. 6. Effect of pump speed on injection lag, maximum pressure and fuel injection for the same conditions as Fig. 5 (left)

Parallel Operation *of* Gas Engines

Operating Prime Movers in Parallel Tests the Mettle of the Operator

By EARL PAGETT

OPERATING A PRIME MOVER alone is quite a different problem from operating two or more such machines together on the same load. Steam engines and steam turbines do not usually give much trouble when running in parallel, but due to the fact that governing, through a wide range of load, is more complicated in gas engines, there is usually more difficulty encountered, as operating in parallel will be found to resolve itself into a problem of governing, each engine must be made to take its share of the load.

Difficulty is not usually encountered, so long as there is sufficient load, but if the load falls below a certain point one or the other of the engines may miss firing a charge or two or possibly more, which throws a surge between the two or more machines. This may be detected by violent fluctuations of the indicating hands on the meters if the engines are pulling generators or alternators, or by a squeaking belt, clutch or pulley if the engines are pulling a common lineshaft.

Why They Miss

No difference what system of governing is used, most gas engines are prone to miss-firing at light loads; if qualitative governing is used, the governor valve may cut the mixture back so lean that it will not fire, and if the quantitative system is used, the volume of the mixture may be reduced to the point that it will not fire at extremely light loads. In the case of multi-cylinder engines, one cylinder or any number may be affected. Theoretically, if one cylinder misses, they should all miss, but this hardly ever works out in practice, and it may or may not be the same cylinder or cylinders each time. The best practice is to keep only enough machines on the load so that they will all be pretty well loaded up all the time so near as it is possible, the operation not only being more satisfactory but more economical also. The hard situation is where the load is just a little too heavy for the machines on and not quite enough for the adding of another machine.

Care must be taken in paralleling, for the incoming engine, running light, is more than apt to "miss" and the hands on the synchroscope reverse and drop suddenly away from synchronism at the instant that the operation is about to close the switch. In this case, if there is individual control over each cylinder of the incoming engine, it may be steadied by cutting out one cylinder until synchronism is accomplished and the engine on the load and then the cylinder cut back in again and the engine given its share of the load.

The writer has had a varied experience with gas engines running both singly and in parallel. In one plant a single cylinder, two-stroke-cycle engine pulled a large fan. A positive-pressure blower was added, which necessitated additional power, and a second single-cylinder unit of the same make and size as the first was installed by the side of the first, both belted to a common line shaft through friction clutches.

Making Them Work

This installation worked out satisfactorily, but as the units were on 24 hr. service and equipped with make-and-break igniters which were prone to carbon up and stick after operating for about 10 da., care had to be taken that the engines were shut down and the igniters changed before they began to stick. These engines were not equipped for indicating and the division of the load had to be guessed at as follows: With both engines on the load, and ignition functioning properly on both, the firing cocks on both were opened. If one of the units missed firing occasionally, or fired very lightly, the qualitative governing-valve stem was shortened slightly to enrich the mixture, until both fired alike as judged by the ear, or if the speed was slightly above normal, the engine firing the hardest was "eased down" until both were firing equal.

Sometimes its the Electrical End

It was also the writer's good fortune to have charge of four large double-acting tandem horizontal units directly connected to twenty-five cycle alternators on electric traction load, where nearly always three and sometimes four were operated in parallel 18 hr. every day. Electric traction service is severe, due to extreme load fluctuations and many interesting and puzzling things confront the man in charge.

In the way of electrical trouble, an alternator out of step or an exciter with reversed polarity, under load will call for pretty fast thinking and quick action. A sudden overload due to a trolley break or any other abnormal cause may pull the speed of all units down to the point that the voltage drops far below normal and under this condition an alternator may pull out of step,

and if it comes to this, things happen fast and furious. The machine out of step or "upset" as it is sometimes called, seems to take current from the other machines, and over speeds, and it is hard to tell just what might happen if the throttle was not closed on the engine or the main switches pulled, disconnecting the machine from the others.

So much current is flowing, however, that it is dangerous to pull the switch and the procedure should be to close the throttle quickly, trip out the circuit breaker on the circuit affected allowing the voltage to come quickly back to normal, after which the machine will pull back in step and the throttle may be opened on the engine, allowing it to take its share of the load again. The machine affected is identified by the over speeding engine and the meters on the alternator will also swing full around against the limit stops. If the main switches are pulled under this condition, it is obvious that the machine will have to be synchronized and put back on the load in the usual manner.

In the plant that was referred to, each machine had a small direct-current generator, belted from a pulley on the main shaft and these generators were also paralleled to a common bus bar from which the alternators took excitation. Due to a slipping belt, one of these exciters would sometimes reverse polarity which would also cause fast thinking and hot footing to the switchboard. Obviously, the reversed machine must be taken off and may then be restored to polarity by lifting the brushes and closing the main switch for an instant, the brushes may then be replaced, the voltage equalized and the exciter again connected to the bus.

In the way of mechanical difficulty, anything may happen, but probably losing the oil pressure on the hydraulically operated governors is the most disconcerting, temporarily, for if all units are affected, the plant is practically without governing until the pressure is restored, and the engines may run away on light loads and slow down on the peaks. The engines in the plant in question were equipped with automatic trips on the ignition system for safety in emergency, and if these tripped out, the whole plant would die unless someone got to them and reset them quickly.

Air Conditioning Standards

Provisions of an Interim Code Formulated by the Air Conditioning Manufacturers' Association.

IN AN INTERIM code for engineering standards for air conditioning of which some minor modifications are expected, the Air Conditioning Manufacturers' Association included substantially the following as recommended practice. Soundness of the code is evidenced by the personnel of the Technical and Code Committee which formulated it, consisting of Donald French, Carrier Engineering Corp., chairman; F. H. Faust and Elliott Harrington, General Electric Co.; A. F. Karlson, Parks-Cramer Co.; C. E. Lewis, Delco-Frigidaire Conditioning Corp.; A. J. Mallinckrodt, Baker Ice Machine Co.; L. S. Morse, York Ice Machinery Corp.; Dr. L. A. Philipp, Kelvinator Corp.; R. E. Robillard, Frigidaire Corp.; Harry Sloan, Vilter Mfg. Co.; R. M. Stikeleather, B. F. Sturtevant Co.; E. R. Wolfert, Westinghouse Electric & Mfg. Co.; Dr. J. R. Zwickl, De La Vergne Engine Co.

Air conditioning consists of means for ventilation, air circulation, air cleaning and heat transfer with control to maintain temperature and humidity within prescribed limits. For summer, the conditioning will include dehumidifying and for winter will include humidifying.

Design load or capacity to maintain specified inside conditions of dry and wet bulb temperatures or relative humidity, also with number of occupants, their activity and other sources of load, including air required for ventilation, must cover heat loss or gain by conduction through walls, doors, windows, ceilings and floors, heat and moisture from incoming air, from occupants and from lights, machinery and appliances, heat from direct sun effect in summer. The time of day that maximum load is expected to occur must be specified, also extremes of dry and wet bulb temperatures or relative humidity for outside air.

Specified outside conditions are to be: For heating, minimum dry-bulb temperature that has been recorded on more than 2 per cent of the days of heating season over a 10-yr. period; heating season includes all days when average daily outdoor temperature was 65 deg. F. or less. For cooling, outside conditions are to be taken as the 10-yr. average of highest dry and wet bulb temperatures, after excluding higher temperatures that have occurred on only 10 days and for less than 3 hr. a day. Inside summer conditions for comfort will be, on the average, as follows, occupancy being over 40 minutes:

SUMMER COMFORT CONDITIONS

Outside	Inside Conditions		
Dry-Bulb	Temperatures		Relative Humidity
Temperature	Dry-Bulb	Wet-Bulb	Per cent
85	74	64	60
85	74	59	35
90	77	67	62
90	80	63	40
95	79	68	58
95	82	65	40
100	80	69	58
100	83	65	38
105	81	70	58
105	84	66	39

For summer cooling, infiltration of hot air through outside doors in cubic feet per minute per persons in the room is to be taken as:

INFILTRATION THROUGH DOORS

Passing of Persons Through Doors	Cubic Feet per Min. per Person 72-in. revolving Door	36-in. swinging Door
Little	2.0	2.5
Moderate	2.5	3.5
Active	4.0	5.0
Large	5.5	7.0
Continuous	6.5	8.0
Doors Wide Open	1200	800

Air inleakage per foot of crack around windows, for wind velocity 10 mi. per hr., will be taken as follows:

LEAKAGE OF AIR THROUGH CRACKS

Type of Window	Conditions	Single Window	With Storm Sash
Double Hung Wood Sash	Avg., no weather strips	0.36	0.28
	Avg., with weather strips	0.27	0.20
	Poorly fitted	1.16	0.85
	Poorly fitted and weather strips	0.33	0.27
Double Hung Metal Sash	Avg., no weather strips	0.78	0.60
	Avg., with weather strips	0.33	0.27
Vertical Metal Single Sash	Hollow Sash, pivoted	1.75	1.48
	Residence Casement	0.55	0.40

Door cracks will have twice the infiltration of window cracks.

Ventilation should comply with local ordinances. For summer cooling, cubic feet per person per minute should be allowed as follows:

AIR REQUIRED FOR VENTILATION

Occupancy Condition	Cubic Feet Air per Person per Minute Preferred	Minimum
Large	7.5	5
Average	10.0	7.5
Small (1 person per 50 sq. ft.)	15.0	10.0
Smokers	30.0	25.0

Heat given off by occupants is to be taken as 400 B.t.u. per hour per person for sedentary workers, 660 B.t.u. for moderate activity such as dancing.

Where people are seated, air velocity should be limited to 50 ft. per min. in the space between the floor and 5 ft. above the floor, except in the vicinity of a supply or return grille.

Supply of air, in quantity and temperature, should be such that variation in dry bulb temperature at any level is not over 3 deg. in any part of a room where persons are at work. For cooled air, the temperature difference between air currents and average temperature of space occupied by workers should not be over 2 deg. when air current velocity is 40 ft. per min. or over; not over 3 deg. for lower velocities.

Return ducts should be sized to handle 100 per cent of recirculated air while warming up rooms. Outside air ducts should be able to handle total air circulated for ventilation during mild weather when no heating, cooling or change in humidity is required.

As desirable features for a refrigerating unit for air conditioning systems, investigation of performance by one manufacturer has set up the following: Unit to be completely enclosed so that no seal is needed around the compressor shaft; minimum of care and servicing required; few joints in refrigerant system; convenient access to compressor; positive lubrication; light weight; good running balance; simple, compact condenser and receiver for refrigerant.

These have been met by connecting a high-speed, water-cooled motor direct to the compressor shaft and enclosing the unit in a single casing, sealed but having side plates for access to the unit for servicing; use of intake and exhaust manifolds cast integral with the crank case and cylinder block; forced lubrication from a pump geared to the crank shaft and feeding oil in parallel to all bearings; a condenser enclosed in the liquid receiver shell, and so designed that it can be connected for using cooling water at either high or low pressure; compressor unit and receiver mounted together making all connections short and direct.

Bank Official Reports on Resuscitation Job

THE FOLLOWING interesting letter accompanied an application from the Mississippi Power Co. for an E.E.I. Medal for Mr. Howard. Mr. Howard will get the medal.

THE FEDERAL LAND BANK OF NEW ORLEANS
Hattiesburg, Mississippi.

MR. R. H. RAMSEY,
Mississippi Power Company,
Purvis, Miss.

Dear Mr. Ramsey:

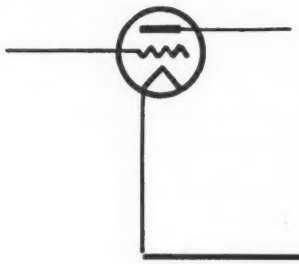
Between four and five o'clock on the afternoon of September 17, I was driving out of Purvis, toward Hattiesburg, when I noticed a negro lying in the street, one block north of the Court House. The negro was unconscious and was holding a live wire with both hands. He first attracted my attention because of the smoke that came from the contact of the wire with his hands.

I turned around and stopped my car, then got out and looked for a dry stick with the idea of knocking the wire from his grasp. It had been raining and it was not possible to locate dry wood near the scene of the accident. At this time I saw a Power Company truck coming. Before the truck skidded to a stop, a tall red headed boy about twenty-four years old, whose surname is Howard, jumped out and jerked the wires loose from the negro. He proceeded to turn the negro over and began giving him artificial respiration. The negro's eyes were glazed, his mouth open and his tongue hanging out. I asked Howard if he had a pulmotor in the truck. He replied in the negative. I then proceeded to tell him he was wasting his time and that the negro was as dead as he ever would be. Howard replied: "Maybe so, but I am going to do my best to save him." I then got into my car and drove to Hattiesburg.

Last week when I was in Purvis, I saw the negro on the street. He seems to be alright with the exception he has lost some of his fingers on account of the accident.

I am of the opinion that some recognition should be given to Howard for the saving of the negro's life.

Yours very truly,
W. M. GRAHAM.



PART VII. The Gaseous Triode. Action of the gas filled triode and an explanation of its principles by means of a mechanical model. Theory of its action.

Electron Tubes — Principles *and* Applications

By A. W. KRAMER

AS WAS SHOWN in the preceding article, the action, or more correctly, the circuit action of the two-element gas-filled tube is essentially the same as that of the two-element high-vacuum tube. Both types are fundamentally rectifiers, the only difference being that the gas-filled tube is capable of carrying currents of much greater magnitude than the high-vacuum rectifier tube.

Knowing something of the advantages of the use of a grid in the high vacuum tube, it might be assumed that the introduction of such a grid in a gas-filled tube would extend its range of usefulness in the same way that it does in the case of the high vacuum tube. To a certain extent this is true, the introduction of a grid in a gas-filled tube does extend its usefulness, greatly in fact, but it does so in an entirely different way than it does in the high vacuum tube.

In a high vacuum tube the grid exercises almost complete control over the plate current; it can start it, stop it, increase or decrease it, indeed it can cause the plate current to follow any variations of the grid potential no matter how complex or how rapid. It is this almost complete control function of the grid that gives the high vacuum tube its property of amplifying.

As soon as a small quantity of gas is introduced into the tube, however, this "modulating" power of the grid upon the plate current ceases and instead it assumes only the comparatively simple function of "starter." If there is no plate current flowing, the grid can initiate its flow at any time, or, by the same definition, it can prevent the plate current from flowing at all.

The gaseous triode, therefore, is not an amplifier as is the high vacuum tube but simply a relay, similar in action to an ordinary mechanical contactor with this difference however, that once the plate current is established, the controlling voltage (the grid potential) loses all influence over the plate current until such time as the plate voltage might fall to zero. The grid in the gas-filled triode therefore has a sort of "trigger" function; it is able to start the plate current but it cannot stop it.

A Mechanical Thyratron

The action can, perhaps, best be explained by the mechanical analogy depicted in the accompanying diagrams. These diagrams show the operation of a check valve in a pipe line, not an ordinary check valve but a modified check valve designed specially to simulate action of the gas filled three electrode tube, it is in fact a mechanical thyratron.

As will be noted in Fig. 1 and 2 it consists of an ordinary non-return type of valve, A, to which is attached a short movable stop, B, so arranged that when the valve A is closed, the stop rests horizontally on the projection D. If, in this closed position, the movable pin C is raised, the valve is locked in position so that even with pressure on the left side of the valve, the valve remains closed. Under these conditions, it is readily seen that the valve can be opened only by lowering the pin C to a point where it will no longer hold the stop B in place.

The sequence of action is shown in Fig. 3. At 1 the valve is completely closed and even with full pressure on the left side of the valve no flow occurs. At 2, the pin C has been pulled down a small amount. Since its upper part is beveled, it can be seen that this permits the valve to open slightly, and there is some leakage past the valve. At 3, the pin has been moved downward to a point where it is almost ready to release the

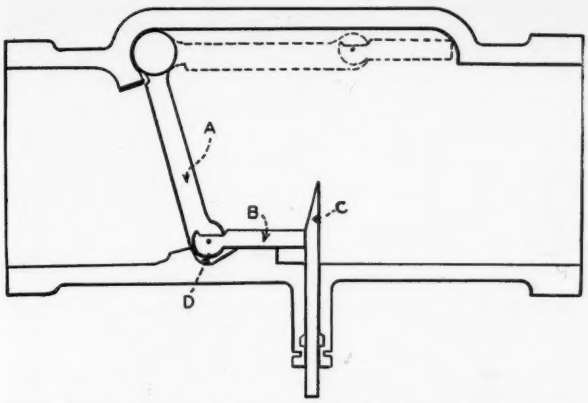


Fig. 1. Mechanical model of a gas-filled three-electrode tube. This is nothing more than a modified non-return valve, equipped with a pivoted stop B and a movable pin C so arranged that the pin C can keep the valve closed against pressure from the left.

valve. At this point the valve has opened an appreciable amount and there is still more leakage past the valve. At this point also, a very slight further downward motion of the pin C will suddenly release the valve entirely and the full open position of the valve is attained instantly.

With the valve open and pressure on the line, the flow through the valve will continue as long as the pressure continues. Under this condition the pin C can be moved upward or downward with no effect whatever upon the flow. In other words, the pin has lost all control over the flow.

Should the pressure in the line reverse, or should it reduce to zero for an instant, the check valve would tend to close as in the case of any ordinary non-return valve. Assume that the pin C is up at such a time. It can readily be seen that if no provision were made to avoid it, the pin might interfere with the closure of the valve. The construction of this valve, however, is such that such interference does not occur. The stop, B, is pivoted in such a manner that as it comes in contact with the pin, C, as shown at 6, it rotates on its bearing and thus slides past the pin as shown in 6, 7 and 8. At 8, it will be noted, the valve is entirely closed and locked in position by the stop and the pin. Thus, the pin regains control; even if the pressure is reestablished, the valve cannot open until the pin is withdrawn again.

The simple action almost exactly simulates the action of the thyratron or gaseous triode. The pin, C, corresponds to the grid and its position, up or down, corresponds to the value of the grid potential. The flow through the valve, of course, is equivalent to the plate current.

In Fig. 4 for the sake of comparison, the flow through the valve is shown plotted against the pin movement. As is quite obvious, as soon as the pin is moved slightly due to the bevel, the valve starts to leak and a very small flow is established. This leakage accounts for the steep slope at the left side of the graph. Then as the valve is released the full flow is established as shown by the horizontal part of the graph. For purposes of comparison, the position of the valve and the pin has been reversed.

Now, compare this graph with the grid-potential plate current characteristic of the gas-filled triode shown in Fig. 5. As will be seen, it is identical with the graph of the valve which has just been analyzed. With a high negative potential on the grid, there is no current through the tube (— 30 v. in this example). As this negative voltage is reduced, a very small plate current begins to flow, which, of course, corresponds to the leakage through the valve during the early portion of the pin travel. At this point, the gas-filled tube resembles the high-vacuum tube. As the grid potential is still further reduced there comes a time (— 15 v., arbitrarily assumed here) when the gas in the tube ionizes and the tube almost instantly becomes conducting. Maximum plate current flows. In other words, at this instant there is a sudden change in the tube's characteristics; its resistance which until this moment has been very high, now suddenly drops to a low value.

This also, it will be obvious, is the case in the hydraulic analogy. Until the pin has moved to the point where it entirely releases the valve, the resistance to the flow is very high. Then, suddenly, as the valve is released, the resistance drops to a very low value.

In the case of the gas-filled tube also, the plate current rises practically to its full value, limited only by

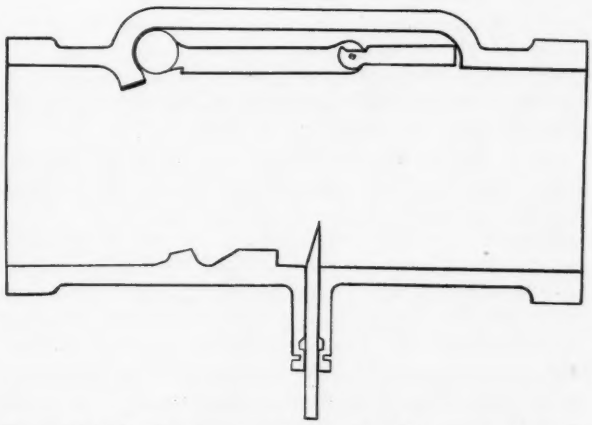


Fig. 2. This shows the same valve shown in Fig. 1 except that here the pin C has been drawn downward allowing the valve to open.

the emission of the cathode or the external resistance in the circuit. With the valve, the flow is limited by the capacity of the pump or head supplying the flow and, of course, by the resistance of the pipe line. Here the pump corresponds to the cathode.

From the foregoing description and explanation it must be evident that the gas-filled, three-electrode tube is a very sensitive current or voltage relay. Also, it is fast in its action—only a few microseconds may be required for the tube to operate, once the proper grid voltage has been attained to permit plate current to flow. Thus, if 15 v. negative on the grid will prevent current flow, a change of say only 0.1 v. to 14.9 v. negative may produce ionization and permit a current of many amperes to flow. Indeed, hundreds or even thousands of amperes may thus be turned on by a mere fraction of a volt applied to the grid. It is, in fact, much like releasing the latch to a gate.

The term Thyratron as used in the General Electric Co. to denote a three-element gas-filled tube means just

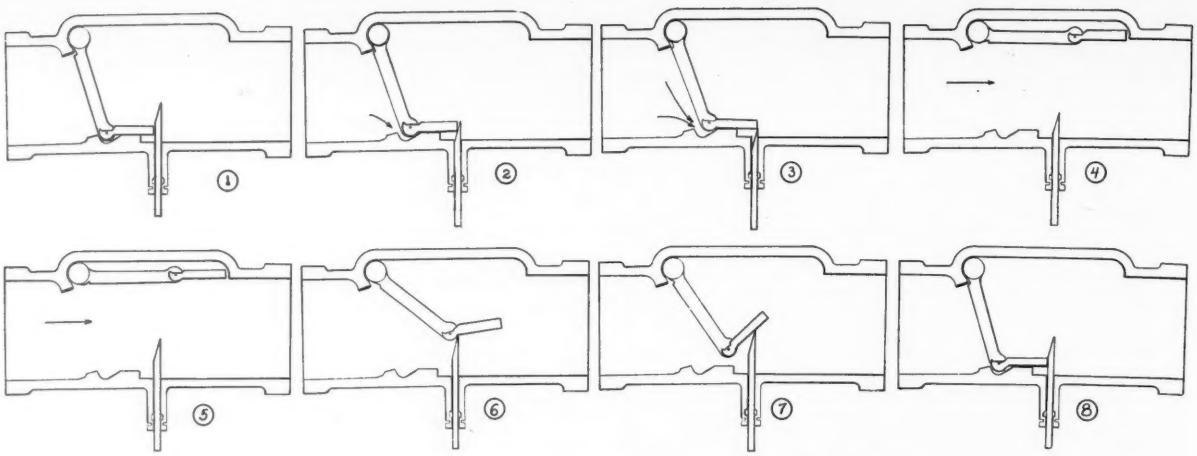


Fig. 3. Sequence diagram, showing the action of the "mechanical" thyratron

exactly that—a gate. Thyratron is one of what De Forest has called the Greco-Schenectady names applied to various kinds of tubes. The suffix "tron" signifies an object that is used as an instrument or tool. Thus kenotron[1] freely translated means "a tool that has nothing in it," the Greek word preceding the "tron" meaning "empty space."

In the same way, thyratron is derived from the same Greek word meaning "door," or "gateway" from which "thyroid" is formed in designating the thyroid gland. Thyratron thus means a "tool or instrument that can be opened like a door."

And that, really, is all there is to it. If you understand this simple action, you understand the fundamental principle of the gaseous three-element tube, otherwise known as the thyratron (G. E.) or the grid glow tube (Westinghouse). True, the "physics" of its operation is more complex and in its application many of the circuits with which it is associated are quite involved, but such complexity cannot be attributed to the tube itself. The tube and its action remain the simple thing we have explained.

Gas filled triodes, obviously, cannot be used as amplifiers as are triodes of the high vacuum type. They *can* be used as rectifiers, just as the two element gas filled tubes but because of the grid and its action upon the plate current these tubes have a much more extended field of use than the ordinary rectifier. The gas filled triode is a special type of rectifier—a rectifier of versatile and amazing possibilities, with properties which adapt it not only for use as a rectifier, but also as an inverter[2] or as a frequency changer. It makes possible electronic voltage regulators or such strange things as direct-current transformers or variable-speed synchronous motors.

[1] Kenotron is the name applied by G. E. to high voltage, high vacuum rectifiers.

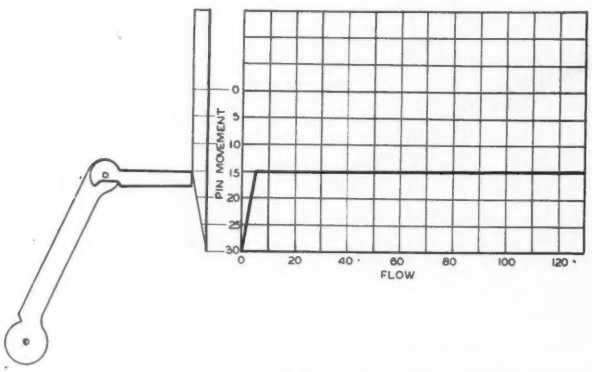


Fig. 4. Diagram and curve showing flow through the valve plotted against pin movement.

Director of the Toilers

As John Winthrop Hammond has expressed it, the thyratron is "the director of the toilers." "In electric circuits of all kinds the restless, tireless, unseen but ever present electrons are the toilers—toilers that light our lamps, run our motors and trains and steamships, that carry our thoughts across thousands of miles of the earth's surface." The thyratron and the other electron tubes are devices which make the electrons do what man wants them to do. They carry out orders with the utmost fidelity by bossing billions and billions of these tiny workers in their role of electrical valves, their open and shut action, allowing electric current to pass or else stopping its passage. No human being has ever directed more than a few millions of his fellow mortals and these have not had a fraction of the immediate supervision over men that the vacuum tubes have over electrons. In the thyratron, a few electrons strategically disposed on the grid—electrical traffic cops so to speak—can hold back thousands of billions of other electrons in their endeavor to reach the plate.

Once the order to move has been given by these grid electrons, the crowd surges forward and thereafter they (the grid electrons) are helpless—they can not stop the forward movement.

This action it will be noted is quite different from that obtained in the high vacuum tube. There, the grid always retains full control of the electron current—it can stop it as easily as it can start it. Let us investigate the reason for this difference.

In the high vacuum tube the potential on the grid serves to aid or oppose the space charge effect. Space charge, it will be recalled[3] is the repelling effect upon

[2] A device for converting direct current to alternating current.

[3] See page 412, July issue.

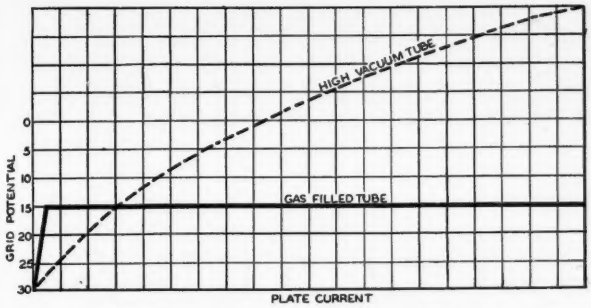


Fig. 5. Grid potential, plate current characteristic of the gaseous triode and also a similar characteristic for the high vacuum tube.

electrons emitted from the cathode of all the electrons in the space surrounding the cathode.

In Fig. 6 is shown a very simple diagram which endeavors to explain this effect. It shows a cathode surface and the positive charges on a grid with the space between filled with electrons. Ordinarily, with no charge of any kind on the grid, these electrons tend to repel those electrons just emerging from the grid. With a positive charge on the grid as shown, however, each positive charge neutralizes the effect of one of the negative charges (electrons) and so the total negative effect is diminished by just that amount. This represents the high vacuum condition.

Suppose, however, that instead of the vacuum the space inside the tube is filled with as many positive ions as there are electrons, as is the case in a gaseous tube in which ionization is taking place. With this condition, shown in Fig. 7, there is, of course, no space charge effect since the effect of each electron is neutralized by that of a positive ion, and since there is no space charge the grid potential can have no effect—the grid is inoperative.

This is not usually the way in which a gaseous triode is operated. Usually the grid is maintained rather highly negative and current through the tube is established by making the grid less negative. However, it is quite possible to arrange a circuit so that the anode potential is insufficient to bring about ionization without the aid of a positive charge on the grid. It is a condition such as this that is depicted in the two diagrams presented here.

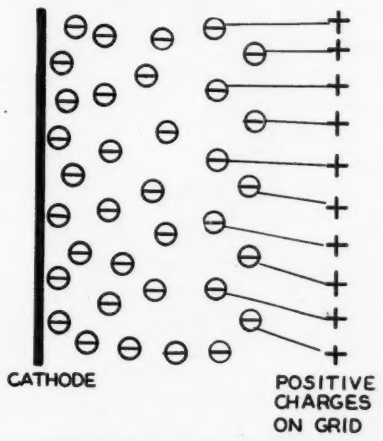


Fig. 6. Diagram showing the conditions which prevail in the high vacuum tube or in the gaseous tube prior to the condition of ionization.

At first, before ionization occurs, the effect of the grid in the gaseous tube is similar to its effect in the high vacuum tube, i.e., it aids or opposes the space charge effect. When ionization occurs, however, the grid loses all influence upon the space charge as has been described.

To continue, suppose under the conditions of ionization described the charge on the grid is reversed, that is it is charged negatively with respect to the cathode. In this case, the positive ions will be attracted toward it, just as they are toward the cathode, and thus the negative charge on the grid will be surrounded by an equal positive charge. Hence, the influence of the negatively charged grid wires extends only a very short distance from the surface of the wire, not sufficient to have any effect on the stream of electrons flowing through it from the cathode to the anode. Having thus permitted the anode current to start, the grid is powerless to stop it.[4]

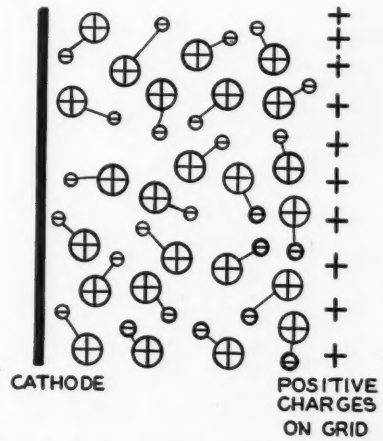


Fig. 7. Diagram showing conditions in the gaseous tube when ionization is taking place

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More Than Half the money spent to date in construction of Grand Coulee Dam has gone directly into industrial centers for the purchase of materials, equipment and supplies according to John C. Page, acting reclamation commissioner. The principal contractor, the MWAK Company has made purchases in 37 states and the District of Columbia in buying $12,973,727.81 of machinery and supplies. The Bureau of Reclamation has made purchases in 23 states in buying $665,353.17 of materials.

While $4,359,218 was spent in Washington State, no effort was made to trace purchases beyond the dealers from whom they were made. Much of this sum went for purchases of articles which are not made in Washington. Other states in which purchases exceeding $1,000,000 were made include: Ohio, where the MWAK Company spent $1,736,267.74 and the Bureau of Reclamation, $8,538.37; Illinois, where the MWAK Company spent $1,466,524.88, and the Bureau, $68,649.30; California, where the MWAK Company spent $1,242,293.24, and the Bureau, $17,262.45; and New York, where the MWAK Company spent $1,231,499.96, and the Bureau, $18,566.20.

[4] This statement, generally, is true although it is possible to build a fine mesh grid, which, made sufficiently negative, will stop the current flow.

Variable Speed Motor Control *with* ELECTRONIC POWER TUBES

By S. R. DURAND
Allis-Chalmers Manufacturing Co.
Milwaukee, Wis.

ENGINEERS CONCERNED with the application of variable-speed drives to paper and textile machinery, printing presses, conveyors, fans, pumps, blowers, crushers, compressors, mine hoists, rolling mills, etc., should be interested in the recent development of a variable-speed drive for d.c. motors employing an iron-tank mercury arc power rectifier equipped with electrically-energized control grids. This type of variable-speed drive is similar in principle to the classic Ward-Leonard drive, but possesses several outstanding advantages for accomplishing speed control in either direction and dynamic braking of d.c. machines.

Iron-tank, mercury arc rectifiers have been used successfully in commercial service for converting alternating current into direct current for more than 25 yr., but it is only within the last few years that rectifiers of this type have been equipped with electrically-energized grids which have made possible voltage control under load and operation of the unit either as a rectifier or inverter of power. It is the principle of voltage control accomplished electronically within the rectifier unit which enables a mercury arc power rectifier to be used in an almost ideal motor drive unsurpassed in respect to regulating range, quickness and accuracy of adjustment, and simplicity of operation.

Figure 1 is a picture of a modern mercury arc power rectifier equipped with vacuum pumps. There are about 3000 iron-tank rectifier units installed throughout the world today, representing a total capacity of over 3,000,000 kw. Rectifiers of this type range in size from one foot to eight feet in diameter and in rating from 10 kw. to 3500 kw., respectively, in a single tank unit.

The circuit diagram of a mercury arc rectifier used for conversion of a.c. power into d.c. power, or vice versa, is shown in Fig. 2. The rectifier is furnished with a transformer which may be designed for direct connection to any distribution system voltage, so that step-down transformers are not required as is frequently the case with motor-generator sets. The direct current terminals of the rectifier assembly are connected to the d.c. motor through a small air-core reactor which serves to reduce the ripple voltage and improve operation of the rectifier unit when dynamic braking is applied to the motor. The field winding of the machine may be conveniently connected to a potentiometer to provide a quick and easy method of reversing the field when dynamic braking or reverse operation is required.

The grid circuit comprises simple and inexpensive apparatus, and requires only a few watts of power for controlling many kilowatts of electrical energy. For rectification control, the grid circuit consists essentially of a grid transformer, a source of d.c. bias, and a potentiometer for adjusting the bias voltage applied

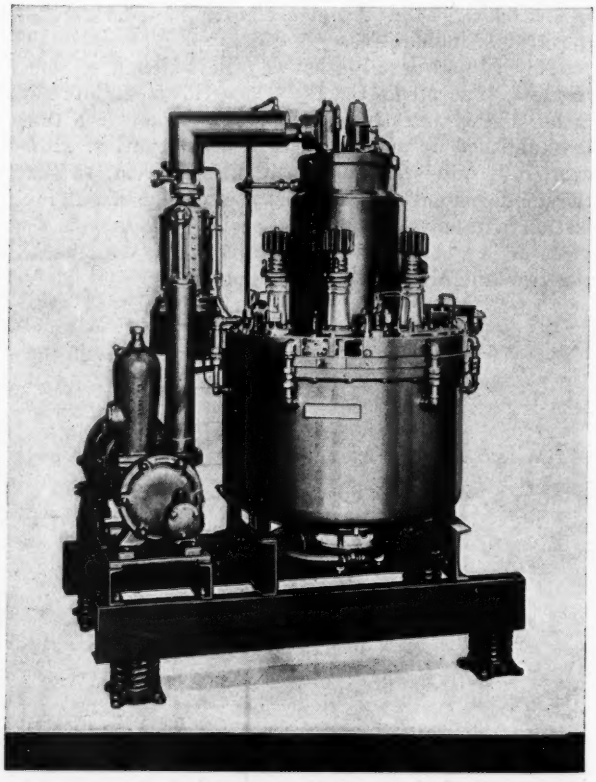


Fig. 1. Modern Mercury Arc Power Rectifier

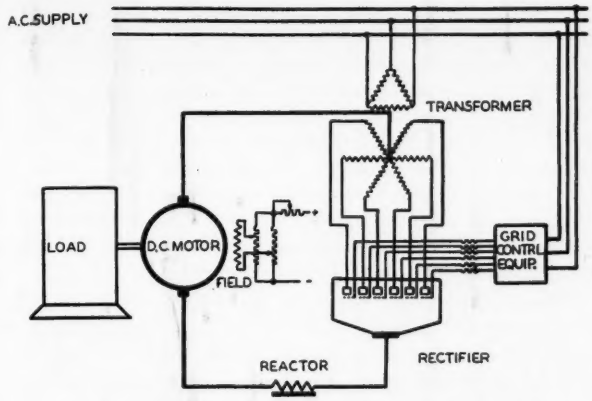


Fig. 2. Variable-speed motor drive with rectifier control

to the grids and thereby regulating the d.c. output voltage of the rectifier unit. For inversion control as required for dynamic braking, the grid circuit also includes a switching device for transferring the control from one grid transformer to another in order to regulate the firing period of each anode of the rectifier unit during the inverse cycle of its applied voltage wave.

Whereas it is possible to use either a series or shunt wound motor for a variable-speed drive with rectifier control, the shunt wound motor is preferable for a large drive if operation at greatly reduced speed is required over a long period of time. This is due to the fact that the power factor of the primary current is reduced proportionately to the amount of voltage reduction required by grid-control of the rectifier unit, so that over a wide range of speed, the shunt type motor would generally require the least amount of voltage reduction for a constant or variable torque drive. For drives of small capacity, operation at reduced power factor is usually of little consequence. Of course, power factor correction can be accomplished by the use of a few taps on the rectifier transformer with grid-control voltage regulation between taps or by the use of condensers, but as far as power factor is concerned even without correction this type of drive with rectifier control is no worse than a three-phase commutator motor drive and is better than an induction motor Ward-Leonard set.

Voltage control of a mercury arc power tube is dependent upon the principle that when a negative potential is maintained on a grid, it will prevent the corresponding anode from igniting and carrying current, but the instant a positive potential is placed on the grid, it will release the anode and allow it to fire. Grid-control regulation provides only for reducing the average d.c. output voltage of the rectifier without requiring any change in the a.c. voltage applied to its anodes. The maximum d.c. output voltage obtained is therefore a function of the transformer voltage impressed on the anodes, so that the rectifier transformer ratio must be chosen to provide an output voltage corresponding to full speed of the d.c. machine.

An understanding of the manner in which the d.c. output voltage of a six-phase mercury arc power tube is regulated by means of grid-control to adjust the speed of a motor can be obtained by reference to the theoretical voltage diagram of Fig. 3. Under normal operation at full d.c. output voltage as shown at the left hand edge of the diagram, each anode fires in turn and carries current during the time it is at highest positive a.c. potential in relation to the other anodes. A.C. power is thus rectified by the mercury arc tube and supplied as d.c. power to the motor at maximum positive voltage. It is apparent in the left hand half of the diagram under "Rectification" that as the firing of the anodes is delayed progressively more and more, the average d.c. output voltage can be reduced to zero. The motor can be brought to a stop in this manner without disconnecting the a.c. power supply, or it can be adjusted to rotate at any desired speed simply by regulating and maintaining the required value of d.c. output voltage by means of grid-control of the rectifier unit.

Figure 4 is a curve showing the relation between the average d.c. output voltage of the rectifier as a function of the angle of delay of the firing period of the anodes under grid-control regulation. It is apparent from this curve that a very smooth control of the output voltage of the rectifier can be obtained from zero to full value, so that continuous regulation of the speed of the d.c. motor can be had from standstill to full speed of the machine. In actual operation the ripple voltage during regulation as shown on the theoretical voltage diagram is materially reduced due to the smoothing effect of the d.c. series reactor, the transformer windings, and the inductive reactance of the entire circuit, so that the average d.c. output voltage

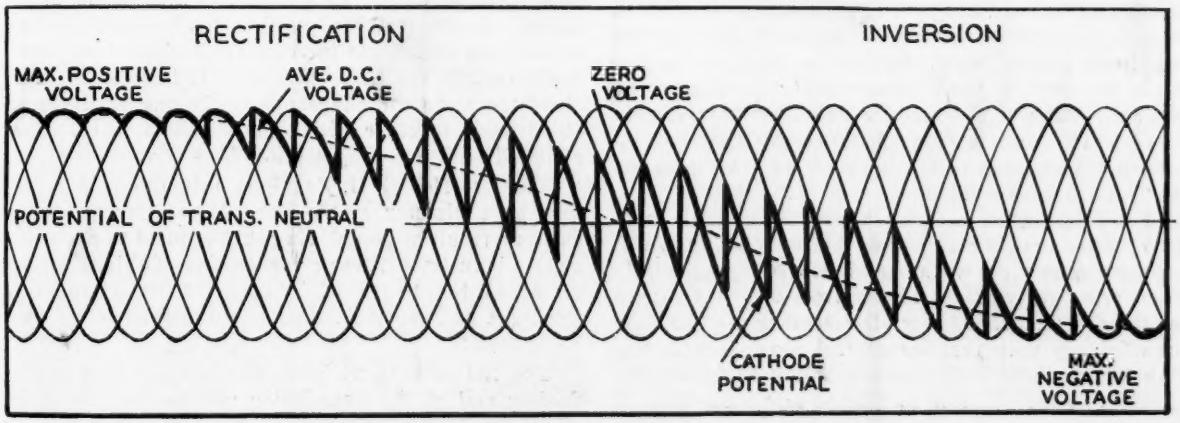


Fig. 3. Theoretical voltage diagram showing rectifier control

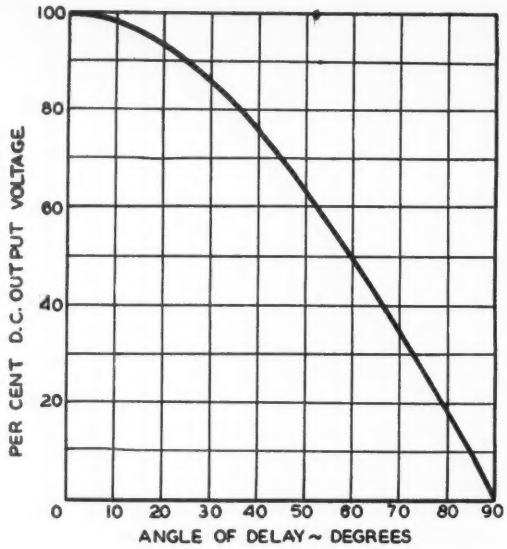


Fig. 4. Regulation of d.c. output voltage of a six phase rectifier as a function of the angle of delay

can be read very accurately on a d.c. voltmeter connected across the machine.

One advantage possessed by this variable-speed drive is that even at very slow speeds the motor can be operated above the knee on the horizontal part of its magnetizing curve so that it can always be run with a high degree of stability. This is particularly beneficial for drives of paper machines, printing presses, hoists, etc., where operation at very slow speeds is often required.

Regenerative dynamic braking of the motor can be accomplished in a very simple manner without requiring the switching of heavy armature currents. It is only necessary to adjust the grid-control circuit of the rectifier unit in order to regulate the firing of the anodes during their inverse voltage waves and to reverse the motor field. Reference again to Fig. 3 illustrates in the right hand half of the diagram under "Inversion" delayed firing of the anodes to the negative part of the applied voltage waves, so that the d.c. output voltage of the rectifier is reversed. The unit is thus made to feed power from the d.c. machine into the a.c. power system. Of course, reversing the field of the d.c. motor causes it to function as a generator, so that the electrical power generated by the machine due to its rotational kinetic energy is rapidly dissipated in the a.c. power system and dynamic braking of the machine is accomplished. The rate of braking the motor in this manner can be controlled by regulating the reverse voltage of the rectifier unit by means of grid control. The voltage diagram illustrates that any inverse d.c. voltage can be obtained from zero up to the maximum negative value.

The efficiency of a variable-speed drive with rectifier control is much better than that of rotating Ward-Leonard converters with speed control, particularly when armature voltages higher than 250 v. are used for the d.c. motor. Of special interest is the fact that the efficiency with rectifier control remains relatively high with reduced load or speed, and at half speed the efficiency is far superior to that of any other type of drive.

One of the principle advantages of a mercury arc power tube for speed control of a d.c. motor is that more than one machine can be connected to a single multiple-anode steel-tank type unit, and each motor by being connected to separate anodes can be independently controlled by means of grid-control circuits. Small auxiliary anodes can also be incorporated in the mercury arc rectifier to supply a constant d.c. voltage to the field circuits of the motors. The stability of operation of any one machine is not effected by the controlled operation of the other machines.

Among the features which characterize this type of equipment are simplicity of control, ease and accuracy with which speed adjustments can be made, quick and simple reversibility of the drive, positive action of dynamic braking, and high efficiency and stable operation of the machine at full speed and even at crawling speeds. Other advantages of this drive include simplicity of starting; insensibility to disturbances on the a.c. system; availability for operation at any system frequency; immunity to dust, metallic vapor, fumes and moisture; high instantaneous overload capacity; quiet operation; low maintenance cost; and ability to control independently several motors connected to a single multiple-anode rectifier unit.

Rackham Engineering Foundation

ARTICLES OF INCORPORATION of The Rackham Engineering Foundation were filed June 12, 1936, in the offices of The Michigan Corporation and Securities Commission by Standish Backus, Alex Dow, Edsel B. Ford, Bryson D. Horton and William S. Knudsen, who are Trustees of the Corporation appointed for life. The new corporation will have title to the $500,000.00 Endowment created by the Horace H. Rackham and Mary A. Rackham Fund for the benefit of the engineering professions and allied arts and sciences in the Detroit area, and for the assistance of the public in meeting engineering problems.

Under the plan adopted, the net income from the Endowment will be paid to The Engineering Society of Detroit, incorporated April 15, 1936. The purposes of this Society are educational and scientific. Its aims will be to aid the public to solve the civic questions involving engineering problems, to encourage research in the investigation of engineering questions of public interest, and finally to provide in its headquarters library service, lectures, publications and instructions on subjects tending to increase the technical skill and social usefulness of the members. It is expected that all of the societies and groups in the engineering and allied fields together with their members will become affiliated with The Engineering Society of Detroit.

The late Horace H. Rackham accumulated his fortune as a director of the Ford Motor Car Company and as a result of engineering skill applied to the automotive industry. It was a recognition of this fact that prompted the Board of Trustees of the Horace H. Rackham and Mary A. Rackham Fund to create this Endowment.

For the present, at least, the headquarters of the Society and of the Foundation will be maintained in the Hotel Statler, Detroit.

High Pressure Power Cycle *and* District Heating

Modern high pressure, high temperature equipments offers increased efficiency and opportunity for by-product power.

THAT THE superimposed high-pressure, high-temperature steam cycle has economic application in the field of district heating was pointed out in a paper by Henry Kreisinger, Research Engineer of Combustion Engineering Co., before the National District Heating Association at Grand Rapids, Michigan, on June 18th. This is especially true where there is a substantial demand for steam during the entire year, the base load steam being passed through high-pressure turbines for generating power before passing to the steam distribution system.

Figure 1 shows the distribution of heat of the fuel burned in power generating plants operating at five different steam conditions. The auxiliary power is higher in the first two columns because more power is used by the feed pumps. The largest rectangles of each column represent the condenser losses which is the principal item where heat loss can be materially reduced by using the high-pressure, high-temperature cycle. The top rectangles represent the boiler room losses which are the same in percentage of the heat in fuel burned for all pressures and temperatures; in other words, the steam generating efficiency is taken as the same in all cases. The total height of each column is proportional to the amount of coal burned per kilowatt-hour of output and, therefore, is also proportional to the size of coal handling equipment, the coal preparation equipment in a pulverized coal plant, the size of stoker in a stoker-fired plant, and the size of steam-generating unit. The condenser loss rectangle is proportional to the condenser size and its auxiliaries. The first column represents the most recent designs of high-pressure power generating plants. The height of the column indicates that a net kilowatt-hour can be generated on 11,800 B.t.u. The steam cycle includes four stages of steam bleeding from the turbine for feedwater heating.

Column 2 represents a steam cycle with 1200 lb. pressure and 740 deg. F. temperature at the turbine throttle. Steam is reheated with high-pressure steam between the high and low-pressure turbine at about 80 lb. This cycle also includes four stages of turbine bleeding for feedwater heating. The heat rate per net kilowatt-hour is about 12,300 B.t.u. Reheating with high-pressure steam has as its main objective the re-

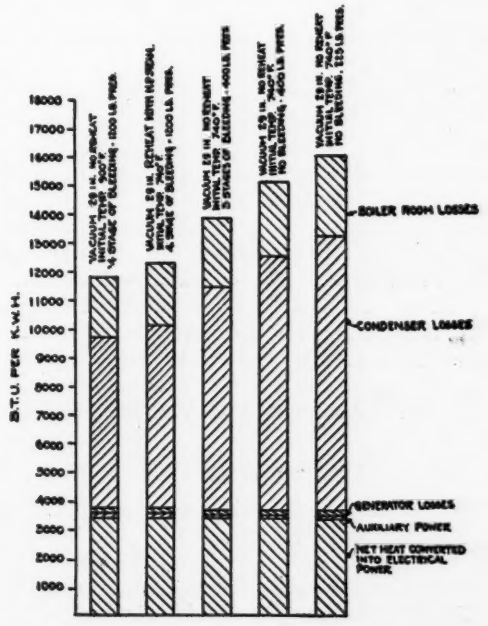


Fig. 1. Diagram showing the heat distribution of five power generating cycles operated under various conditions of pressures, temperatures, turbine bleeding for heating feedwater, and reheating feedwater, and reheating steam, as indicated at the top of each column

duction of moisture content in the expanded steam. It does not add materially to the thermal efficiency of the cycle because there is some degradation of heat in the transfer of the latent heat in high-pressure steam to somewhat lower temperature of the heat in the superheated low-pressure steam.

Columns 3 and 4 represent cycles with steam at 400 lb. pressure and a temperature of 740 deg. F. at the turbine throttle. The difference between the third and fourth columns is that in the cycle of the third column three stages of turbine bleeding are used for feedwater heating. The last column represents a cycle with a steam pressure of 225 lb. and 740 deg. F. steam temperature. The initial temperature is somewhat higher than would be necessary. It has been used to

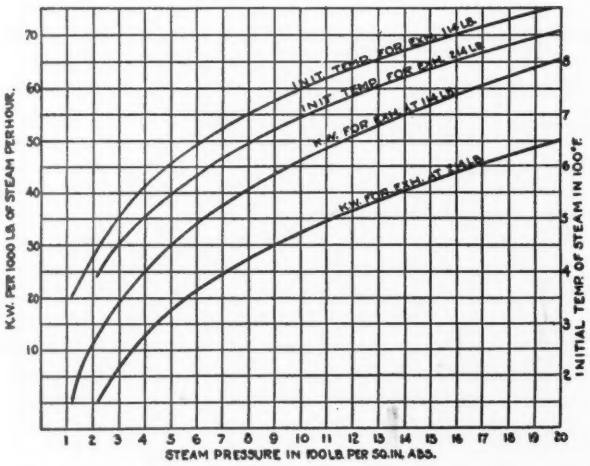

INIT. TEMP. FOR EXH. 114 LB.
INIT. TEMP. FOR EXH. 214 LB.
K.W. FOR EXH. AT 114 LB.
K.W. FOR EXH. AT 214 LB.
K.W. PER 1000 LB. OF STEAM PER HOUR.
INITIAL TEMP. OF STEAM IN 100°F.
STEAM PRESSURE IN 100 LB. PER SQ. IN. ABS.

Fig. 2. Chart showing the amount of power that can be generated by superimposing high steam pressure and temperature ing steam, as indicated at the top of each column

make this cycle more comparable with the cycles of the third and fourth columns.

This diagram is intended to show to what extent the high-pressure and high-temperature steam cycle reduces the size of steam generating and condensing equipment. It also indicates how the reduced size of this equipment partly balances the increased cost of stronger and heavier high-pressure construction. The condenser losses are to some extent a measure of the amount of steam that may be made available for heating purposes in a case where high-pressure steam power generating cycle is superimposed on a heating system. They also indicate that with a given base heating load more power can be generated by using the highest practicable superimposed steam pressure.

Superheat Required

The business of generating power and the business of generating steam for distribution for heating purposes and similar uses are closely associated, and in many cases are becoming merely departments of one consolidated business. By careful planning of the design and location of the central station, a substantial part of the power can be generated with nearly 100 per cent thermal efficiency because a large part of the heat in the steam now going to the condensers and wasted in the cooling water can be utilized as heating steam.

Because little or no superheat is required for steam heating, the initial temperatures of the high pressure steam of the superimposed power generating cycle may be only moderately high. Thus, high pressures can be utilized to advantage without the necessity of very high initial temperature. It is the high initial temperature required for the high pressures in the power generating station that presents intricate problems. At the present state of the art high pressures are more easily provided for than high temperatures.

Figure 2 shows how much power can be generated per 1000 lb. of steam with a given initial pressure and temperature, and exhausted from the high-pressure turbine into a heating system at either 214 lb. or 114 lb. absolute pressure. The scale at the right indicates the initial temperature in 100 deg. F. that must be used with any initial pressures to give about saturated steam when exhausted into the heating system operated either at 114 or 214 lb. pressure. The two lower curves are to be used with the scale at the left and the

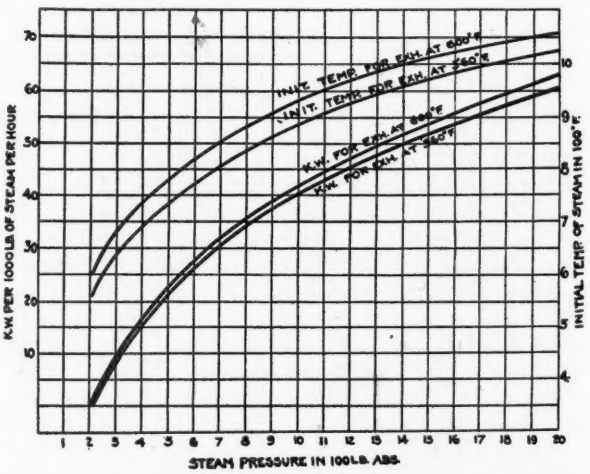

INIT. TEMP. FOR EXH. AT 600°F.
INIT. TEMP. FOR EXH. AT 560°F.
K.W. FOR EXH. AT 600°F.
K.W. FOR EXH. AT 560°F.
K.W. PER 1000 LB. OF STEAM PER HOUR.
INITIAL TEMP. OF STEAM IN 100°F.
STEAM PRESSURE IN 100 LB. ABS.

Fig. 3. Chart showing the amount of power that can be generated by a high-pressure and high-temperature cycle superimposed on an old plant operating at 214 lb. absolute pressure and either 560 or 600 deg. F. total temperature

two higher curves with the scale at the right. The lowest curve gives the amount of power that can be generated with high-pressure steam when exhausted at 214 lb. pressure and 5 deg. superheat.

From this it will be seen that for an initial pressure of 1200 lb. about 36½ kw-hr. can be generated for each 1000 lb. of steam per hour. The initial temperature necessary with this 1200 lb. pressure to give 5 deg. superheat at 214 lb. exhaust pressure is 730 deg. as indicated by the third curve and the scale at the right. If the heating system is operated at 114 lb. the second curve and the scale at the left gives the kilowatt-hours per 1000 lb. of steam, and the fourth curve with the scale at the right indicates the necessary initial temperature for 5 deg. superheat in the exhaust steam. The initial temperature in this case is about 785 deg. F. The curves were prepared for 80 per cent efficiency of steam expansion in the turbine and generator losses of 5 per cent of the energy represented by the 80 per cent steam expansion.

Superimposition of the high-pressure cycle on a heating system is particularly well adapted to many industrial plants and industrial districts where large amounts of steam and power are required at all seasons. In such cases the initial pressure can be chosen to balance the demand for power and the demand for heating steam. The industrial plants have been quick to see the advantages of superimposition of power generating cycle on their steam heating systems. Many of them have already installed high pressure equipment to supply their power and heating steam, and many more are planning to do so in the near future.

In connection with district heating, study should be made also of the possibility of increasing the use of steam in summer and of power in winter. Such studies should be directed particularly to new uses of steam and power that would make the base load as large as economically practicable. There is also a possibility that some advantage might be gained by the variation of exhaust pressure. In winter when the heating load is heavy the exhaust pressure might be 200 lb.; in summer the pressure could be dropped to 150 or 100 lb. Lower exhaust pressure in summer would make it possible to generate more power with the steam demanded for heating, and thereby reduce the amount of steam condensed in the power generating station. A lower exhaust pressure would be sufficient to move a smaller weight of steam of the summer load through the heating system. There might be also a small gain in power by raising the initial pressure. It is true that such pressure changes would change the condition of the exhaust steam from small superheat to moisture; but this might not be a serious objection. Such possibilities should be given consideration when designing the superimposed power-generating equipment. When a new steam distributing system is laid out, it might be well to design it for the higher pressure of the heavy winter load.

Figure 3 shows a relation similar to Fig. 2, applied to cases where the high-pressure and high-temperature cycle is superimposed on low-pressure power generating plant using steam at a gage pressure of 200 lb. and superheat temperature either at 560 or 500 deg. F. If the low-pressure plant is designed for 200 lb. pressure and 560 deg. F., the lowest curve is used with the scale at the left to give the kilowatts per 1000 lb. of steam per hour, and the third curve is used with the scale at the right to give the initial temperature of the high-pressure steam necessary to give a temperature of 560 deg. F. of the steam to the old turbine. Thus, with initial steam pressure of 1200 lb. and the temperature of steam to the low-pressure turbine at 560 deg. F., the lowest curve shows that about 46 kilowatts can be obtained per 1000 lb. of steam per hour, and the initial temperature as given by the third curve with the scale at the left is 930 deg. F. If the temperature to the low-pressure steam is to be 600 deg. F. the second curve from the bottom indicates that about 47 kilowatts can be generated per 1000 lb. of steam per hour, but that the initial temperature given by the highest curve is 970 deg. F. The curves are calculated with the assumption that the efficiency of expansion in the high-pressure turbine is 80 per cent and that the generator losses are 5 per cent of the energy represented by the 80 per cent expansion efficiency of high-pressure steam. The initial temperatures of the high-pressure steam are considerably higher in the case where the high-pressure cycle is superimposed on an existing low-pressure power generating plant, than when similar superimposition is made on a heating system, because the exhaust steam from the high-pressure turbine must be delivered to the low-pressure turbine with considerable superheat.

Comparison of Figs. 3 with 2 shows the advantages of superimposing the high-pressure cycle on a heating plant over the superimposition of high-pressure cycle on a low-pressure and power generating equipment. To avoid the extremely high initial steam temperature the low-pressure stages of a new high-pressure condensing turbine are designed to handle high percentage of moisture in the steam.

Carrier Pilot Installation for T. V. A.

CARRIER PILOT RELAYS, the fastest relaying equipment available, will be used to protect the 230-mile, 161,000-v. transmission line connecting Norris, Wilson, and Wheeler Dams on the federal government's huge T. V. A. project. During a portion of the year this system is subjected to severe electrical storms which despite all reasonable precautions will occasionally cause short-circuits. Carrier pilot relays, provided by the General Electric Company, will be used to determine the tripping of the breakers whenever short-circuits occur. This type of relaying will be applied to both sections of the transmission line to insure a maximum of reliability and continuity of service on the system. These relays operate in 1/60 sec. after the start of fault conditions and in conjunction with the high speed circuit breakers will ordinarily clear the defective section completely in less than 15/100 sec. Because of the pilot principle, carrier pilot relaying is entirely selective in its operation so that only the faulty section is cleared and the remaining sections are kept in service for the transmission of power.

The 161,000-v. capacitors which are used to couple the carrier frequencies to the transmission line will perform double duty by also supplying voltage for the operation of the relays. This is accomplished through the use of potential devices connected between the coupling capacitors and ground.

In addition to this relaying equipment, the General Electric Company will also supply a carrier-current telephone system utilizing the transmission line conductors. With this system communication maintained between the plants when the lines are in service and also when they are removed from service for maintenance. Carrier-current line traps will be applied to keep the carrier frequency channel operative when the lines must be removed from service and grounded.

In addition to providing communication between the three generating stations, equipment will also be located at two substations. These facilities may easily be expanded as required by the growth of the project.

Seals *against* Fluid Pressure

Part IV. Specifications for Gaskets, Diaphragm Packing and Fabric Packing for Condenser Tubes

WITH THE STANDARDIZATION of pipe flanges, handholes and manholes, manufactured gaskets became commercially practicable and the necessity of cutting these gaskets from sheet packing no longer exists except on emergency occasions. The practice in modern plants is to carry a supply of the commonly used gaskets in store in addition to a variety of sheet packings from which specially shaped gaskets can be cut. High temperatures and pressures have demanded a service of gaskets beyond that which can be rendered by ordinary sheet packing, metallic reinforcement or encasement being found most satisfactory. Such gaskets are not easily made as they require special machinery for their manufacture and are usually patented products with features adapting them to specific purposes.

General specifications, however, have been drawn up which cover purchases made by the U. S. Federal Government for use in the Navy and Government buildings, and these requirements are an excellent guide in the selection of manufactured gaskets. The salient features of these specifications are given in the paragraphs which follow.

Asbestos-Copper, Corrugated Gaskets

Corrugated gaskets made of copper inlaid with asbestos are specified in only one grade and are recommended as suitable for use on joints with steam to 300 lb. pressure and 700 deg. F. temperature. These gaskets are composed of corrugated annealed copper, all corrugations being filled with twisted or braided asbestos cord. The corrugated disks are made of sheets not less than 0.018 in. thick, containing not less than 99.5 per cent copper and are annealed before and after pressing and rolling.

For filling corrugations, the cord used is required to contain not less than 85 per cent of long fibre asbestos of not less than 12 per cent water of composition. The inside diameter of the gasket must be not less than ¼ in. larger than normal inside diameter of pipe sizes up to and including 12 in.; and at least ½ in. larger on all gaskets above 12 in. diameter of flange. The test for compression strength is to subject the gasket for one minute to a load of 1250 lb. per sq. in. after which it is required to regain its original size or thickness upon releasing the pressure.

When purchasing this type of gasket, it is necessary to give both inside and outside diameters, ring gaskets for pipe flanges must fit inside the bolts.

Asbestos, Metallic-Cloth Gaskets

Gaskets coming under these specifications are made in two grades and two types, Grade I having not less than 90 per cent asbestos and Grade II not less than 75 per cent, Type A being seamless and Type B jointed.

Grade I gaskets are suitable for flange joints for steam to 300 lb. pressure, and 700 deg. F. temperature, for hot or cold water or brine to 300 lb. pressure, for air to 3000 lb. pressure or for gases of combustion to 725 deg. F. temperature.

Grade II gaskets are applicable to flange joints for steam to 200 lb. pressure and 500 deg. F. temperature, or for hot or cold water or brine to 200 lb. pressure, or for air to 200 lb. pressure.

All folded gaskets for boiler manholes, handholes and flanged joints are included in this specification. Handholes and tube plate gaskets may be either Type A or Type B, all other gaskets should be Type B.

The material used in these gaskets is woven asbestos wire-insertion cloth, all layers of which are uniformly impregnated with rubber compound.

Seamless gaskets, Type A, are composed of an integral piece of fabric in which the filler threads run continuously around the gasket, while the warp threads run transversely. The jointed gaskets, Type B, are composed of cloth cut on the bias and folded into the required shape and thickness after the ends have been securely jointed together. In construction the fabric is folded on itself to form the desired thickness, the fold forming the edge of the gasket which is exposed to the steam or liquid pressure. All gaskets under this specification must be ⅛ in. in thickness and greater, they are folded and contain not less than three plies of cloths.

Wire used in these gaskets may be either brass or copper 0.007 in. in diameter with a plus or minus tolerance of 0.001 in. The finish required is such as to retain the shape and size of the gasket under ordinary conditions of handling before and during installation. In finished dimensions of the gasket, no minus tolerances are permitted, allowable plus tolerances, however, are as follows: 1/32 in. in thickness in all gaskets, 1/32 in. in all other dimensions when the inside

perimeter is 20 in. or less, 1/16 in. in all other dimensions when the inside perimeter is more than 20 in. Under a bend test, the gasket must not crack or show any signs of injury when bent flat upon itself.

Grade I requires that the cloth shall be woven from yarn containing not less than 90 per cent, by weight, of long fiber asbestos of not less than 12 per cent, by weight, water of composition. The weave of the cloth consists of not less than 20 strands in the warp and 10 strands in the filler per linear inch. For ⅛ in. three-ply gaskets the cloth used is constructed with each strand of warp consisting of two plies of asbestos yarn and one brass or copper wire twisted together, each strand of the filler is composed of one

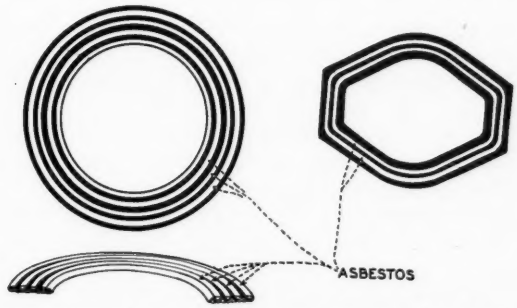


Fig. 1. Asbestos-Copper Corrugated gaskets are designed for high pressures and temperatures

or more plies of asbestos yarn and one brass or copper wire twisted together. For 3/16-in., three-ply and ¼-in., four-ply gaskets, the cloth is required to have each strand of the warp and filler consist of two plies of asbestos yarn and one brass or copper wire twisted together. The asbestos metallic cloth before application of the rubber compound is required to weigh not less than 2.25 lb. per sq. yd. for ⅛-in. three-ply gaskets and 2.75 lb. per sq. yd. for 3/16-in. three-ply and ¼-in. four-ply gaskets. The rubber compound used must be not less than 40 nor more than 50 per cent, by weight, of the finished gasket. Under steam test these gaskets are required to show no signs of flowing, cracking, material hardening, or disintegration of the rubber compound when bolted between iron plates and subjected to the action of saturated steam at 275 lb. pressure for a total of 24 hr.

Grade II gaskets require that the cloth be woven from yarn containing not less than 75 per cent, by weight, of long-fiber asbestos of not less than 12 per cent water of composition. The weave of the cloth is not less than 16 strands in the warp and 8 strands in the filler per linear inch. Cloth for ⅛-in., three-ply gaskets is made up of strands of warp each of which consists of two plies of asbestos yarn and not more than two brass or copper wires twisted together, and each strand of the filler is composed of one or more plies of asbestos yarn and not more than two brass or copper wires twisted together, provided that not more than one wire is used in the filler when only one ply of yarn is used. Cloth for 3/16-in., three-ply and ¼-in., four-ply gaskets is woven with each strand of the warp and filler consisting of two plies of asbestos yarn and not more than two brass or copper wires twisted together. The weight of the asbestos metallic cloth before application of the rubber compound must not be less than 2.25 lb. per sq. yd. for ⅛-in., three-ply gaskets and 2.75 lb. per sq. yd. for 3/16-in., three-ply and ¼-in., four-ply gaskets. The rubber compound must not exceed 55 per cent, by weight, of the finished gaskets. The steam test for Grade II gaskets is conducted with steam at 200 lb. pressure for 24 hr.

Metallic-Encased Gaskets

Specifications for metallic-encased gaskets separate them into two types, Type A being metallic-asbestos and Type B, metallic-cork. Type A gaskets with single jackets are suitable for exhaust systems of internal combustion engines, air compressors, and other connections subject to temperatures of 150 to 500 deg. F. and pressures up to 200 lb. per sq. in. Type A gaskets with single jacket and metal inlay, double jacket, or with wound strip construction should be used for steam joints and other services where the temperature is above 500 deg. F. and the pressure above 200 lb. per sq. in.

Type B gaskets are suitable for fuel, water and air connections of internal combustion engines at pressures up to 200 lb. per sq. in. and temperatures up to 150 deg. F. Single jacket without inlay should be used.

Copper is usually used for the jacket or strip of metallic encased gaskets, but when required for a particular service, such as contact with ammonia, some acid or chemical that would readily attack copper, another more suitable metal should be substituted. Brass, steel, zinc, aluminum, monel metal, or lead may be used as substitute for copper.

Considerable leeway as to the construction is left in the specifications to the manufacturer of the gaskets. One form is constructed with a single jacket without

Fig. 2. Gaskets made of asbestos metallic cloth are applicable to a variety of medium and high temperature services

inlay, another has a single jacket with metal inlay, or a double jacket, so formed as to surround almost completely the asbestos or cork core. The seams of the jackets or any exposed part of the core is on the top or bottom side and not on the edge of the gasket exposed to the gaseous or liquid pressure. Another permissible form is constructed with a single strip of metal wound in spiral dovetail shape, starting on the inside and working out ply by ply to the desired size. Between plies of metal is a cushion of asbestos spirally wound to conform with the metal strip. The metal used for these gaskets is commercial annealed copper, unless otherwise specified, which is not less than 0.008 in. and not more than 0.015 in. thick.

In dimensions of the finished product no minus tolerance is permitted but a plus tolerance of 1/32 in. is allowable in the thickness and flange width of all gaskets, in all other dimensions 1/64 in. tolerance is permitted with gaskets with outside perimeter 25 in. or less and 1/32 in. with gaskets over 25 in. in outside perimeter.

Type A gaskets have a core that is composed of

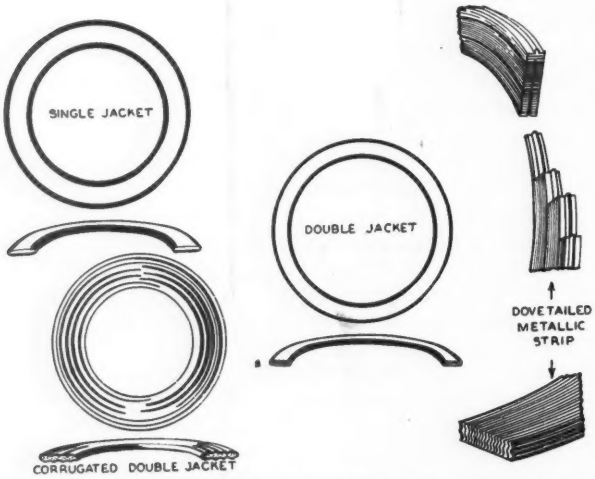


Fig. 3. Metallic encased gaskets are obtainable in several designs

soft asbestos millboard, twisted or braided asbestos. This fiber must not contain less than 12 per cent water of composition. The test for loss on ignition is conducted on a portion of the asbestos core which is dried to constant weight at a temperature not exceeding 221 deg. F. A 2-gram sample of this dried material is then cut up and heated to a bright cherry red in an open crucible in a gas muffle for 30 min. The loss in weight of the asbestos resulting from this test must not exceed 20 per cent.

In Type B gaskets, the core is composed of cork (cork-board) in the forming of which no binder except natural cork gum is permitted to be used. This cork must not disintegrate nor show expansion greater than 2 per cent in any of its linear dimensions after being submerged in boiling water at atmospheric pressure for 3 hr. The cork core is also required to be unaffected when submerged in fuel oil at room temperature for 1 hr.

Diaphragm Packing

Many devices used in power plants employ diaphragms in their construction. The specifications given here apply to diaphragm packing intended for service with hot or cold water or brine at pressures up to 300 lb. per sq. in., they permit of but one grade.

This packing is constructed of two layers of cotton fabric with a layer of rubber 1/16 in. thick between them, and a layer of rubber on each side, the latter layers being of equal thickness. The total thickness of the packing is ¼ or ⅜ in., with an allowable tolerance of 5 per cent, and the width of the rolls is usually 36 in.

Rubber compound used must not contain less than 75 per cent by volume of the best quality of new rubber and must conform to the following chemical and physical characteristics: Acetone extract, maximum, 7 per cent; total sulphur, maximum, 8 per cent; aging, tensile strength, minimum, 1900 lb. per sq. in.; ultimate elongation, minimum, 2 to 11 in., set-stretch for 10 min. 2 to 10 in.; per cent set after 10 min. rest, maximum, 25; friction, minimum, 14 lb.

Fabric used in this packing is square-woven duck weighing a minimum of 14 oz. per sq. yd., having a breaking strength, tested by the grab method on a piece 1 in. by 1 in. by 3 in., of 150 lb. minimum for both warp and filler. The threads per inch of warp and filler are required to be 22 plus or minus 4.

Fabric, Condenser-Tube Packing

In the construction of surface condensers, designers must provide for some play between the tubes and the tube sheet in order to permit expansion and contraction of the tubes which, being made of different metal than the shell, would set up destructive strains if all the connections were solid. Tubes are therefore packed in the hole in the tube sheet with some type of resilient material that will permit slight working of the tube in the hole but still maintain a seal between the water and steam spaces.

For this purpose Federal Standard specifications have been issued only for packing of the fabric type, although there are now in commercial use a number of grades of metallic packing which have proved to be highly successful. These specifications require that the packing must be of braided cotton free from sizing or other loading materials. In construction the packing is composed of cotton strands braided to produce a nominal diameter of ⅛ in. and a weight of not less than 1 lb. nor more than 1⅛ lb. per 200 yd. length of packing. Unless otherwise specified, this packing is furnished without lubrication.

(To be continued.)

On the airship Hindenburg, the power plant for driving consists of four 1200-hp. Diesel engines, 16 cylinder, water-cooled, V-type, at 1400 r.p.m., driving the propellers through 2 to 1 reduction gearing. Starting is by compressed air from bottles which are carried in the engine compartments and charged by 2-stage compressors, driven from the engines through clutches. 143,300 lb. of fuel is carried in 42 tanks and fed to the engine supply tanks by gear pumps.

Electric current is supplied by two 40 hp. Diesel engines driving 30 kw., a.c. generators at 220 v., each unit being capable of carrying the normal lighting and motor load of the ship.

Stems for the gate valves at Tygart River dam at Grafton, W. Va., are made of a special K-monel metal (⅔ nickel, ⅓ copper, with special heat treatment and a small percentage of aluminum). Sixteen of the stems are 18 ft. 5¼ in. long by 7 in. diam.; two others are 12 ft. 9 in. long by 6 in. diam. Tensile strength is close to that for high-grade alloy steels, the highest test showing 162,000 lb. per sq. in., the lowest 144,000 lb., average 153,500 lb. with average yield point 109,500 lb. per sq. in.

Perfection of a Normalized Resistance Welded Tube, Free of Scale

Bright Annealing Boiler Tubes

By CHARLES N. SCHMIDT
Republic Steel Corp.

UNIFORMITY in material, wall thickness, hardness, surface and grain structure are all important and one of the main requirements of pressure tubes. With this in view Steel & Tubes, Inc., subsidiary of Republic Steel Corp. has installed one of the first controlled atmosphere furnaces for the heat treatment of steel tubing. This furnace makes possible the complete uniformity of surface in that tubes can be normalized at 1650 deg. F. without the formation of scale. This tube is marketed under the name of Electrunite.

Raw material is open-hearth hot-rolled strip steel, pickled to remove all scale and then sheared on both edges to accurate width to insure a tube of the proper diameter. Variation in gage of the strip at any cross section rarely exceeds 0.003 in. and since subsequent operations have practically no effect on wall thickness a concentric tube is assured.

The strip is formed cold into a butted tube on a continuous rolling machine and continuously electric resistance welded by the Johnston process. In this process the butted tube is passed directly under a pair of copper discs which act as electrodes, one disc making contact with the surface of the tube on each side of the seam. The lower half of the tube, under the electrodes, is supported by a pair of steel rolls which exert pressure on the sides of the tubes at the instant of welding and force the edges of the seam together.

This process, which includes forming welding and sizing, immediately after the welding, is continuous. The amount of metal extruded both inside and outside of the tube is small and the slight upset or burr formed at the weld is removed by cutting tools inside and outside the tube. When these tubes were first placed on the market the inside burr was rolled or forged down while hot. This was not considered as representative of the best practice and a cutting tool was substituted for the rolls.

Specimens of tubing directly from the welder are subjected to the conventional expansion, flanging and flattening tests prior to the finishing operation when they are again tested.

These tubes have been normalized after the welding operation ever since their inception; that is, they are heated above the critical point of the metal, which in the case of boiler tube steel or 0.08 to 0.18 carbon is 1650 deg. F. Normalizing recrystallizes the steel, relieving welding and cold working stresses and produces a uniform, fine grain micro-structure of uniform hardness. This heat treatment restores uniformity to such an extent that it is virtually impossible to locate the point of weld under the microscope. This is illustrated in Fig. 2, which shows the structure in the "as-welded" condition and the same tube after normalizing.

Up to a few months ago this normalizing was done in a conventional furnace, causing considerable scaling which was afterwards removed by pickling. Possibly it would be very desirable if an absolutely uniform, tightly adherent scale, completely covering the surface of the tube could be formed. However, the scale formed during annealing in the conventional furnace, or during the various hot processes employed in manufacturing other tubes is not uniform, but occurs in the form of small flakes or scales.

If not removed this scale is generally considered undesirable in pressure tubes due to the fact that local corrosion may result due to the difference in potential

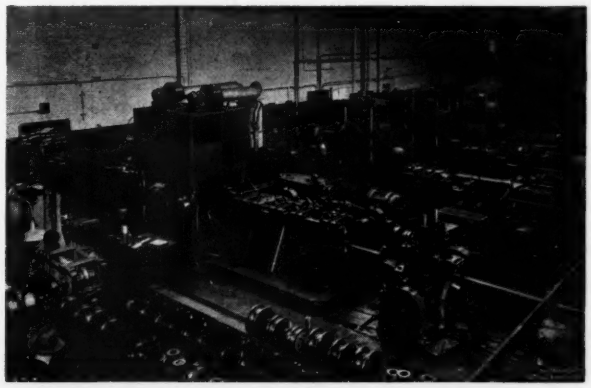


Fig. 1. Johnston welder used in manufacture of boiler tubes

between the scale and the base metal of the tube. In many cases, and this is particularly true with some refrigerants, the scale may become detached from the tubes, causing poor circulation in the unit, or actual obstruction in the lines or mechanism.

To preserve the fine finish and surface which resulted from cold working the original hot rolled strip, the latest type controlled atmosphere electric furnace was installed, and has been in operation for several months. This unit which is said to be the largest of its kind ever made, is composed of the electric furnace

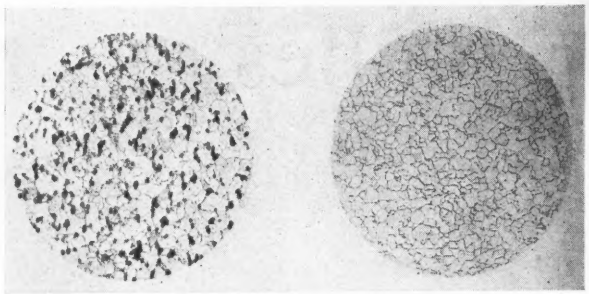


Fig. 2. Microphotograph showing grain structure in as-welded condition (left) and after normalizing (right)

proper, which is 36 ft. long and 4 ft. 4 in. wide inside, and the cooling chamber. This latter section, connected to the furnace, is 78 ft. long and is water-jacketed so the cooling rate may be controlled. The operation of the furnace is continuous.

Tubes are carried through the furnace and cooling chamber on rollers, at the rate of 5000 lb. per hr. A reducing gas, made by partially burning illuminating gas, is passed through a refrigerating unit to remove all moisture, and is fed into the furnace to prevent oxidation, at a rate which always keeps the furnace and cooling chamber slightly above atmospheric pressure, so all leakage is outward. This leakage is burned at both the entrance and exit doors of the unit, hoods with exhaust fans being placed directly above the doors to remove any traces of incompletely burned gases from the building. Temperature controllers are used to maintain the desired temperature at approximately 1650 deg. F. The length of the cooling chamber has been designed so that with the desired rate of cooling the tubes leave the furnace at a temperature at which scaling will not take place.

After normalizing, the tubes are carried by a roller conveyor into a gas fired furnace which is maintained at a temperature of 650 deg. F. This imparts a light blue oxide coating to the tubes, similar to the blueing on a gun-barrel. It was thought that this blue oxide coating would serve in some measure to prevent rust in shipment and storage. The furnace has not been in use long enough to observe the results of the blue coating during seasonal climatic changes, so it is impossible as yet to definitely evaluate the effectiveness of this blue oxide coating as a rust preventative.

After blueing the tubes are straightened, lathe cut to length and hydraulically tested to an internal pressure of 2000 lb. per sq. in. while two air hammers jar the tubes. The requisite number of flanging, flattening and crushing tests are made on each lot in accordance with specifications of the A.S.M.E. boiler code, or customer's specifications.

Fig. 3. Entrance end of the annealing furnace

Practically all organizations which control the construction and operation codes of boilers have made provisions for the use of resistance welded tubes. Case 709 (revised) has been acted upon by the Boiler Code Committee of the A.S.M.E. to cover electric resistance boiler tubes; they are included in Federal Specifications WW-T-731a, issued by the Federal Specification Board, and can be used in either water or fire tube boilers under the rules and regulations of the Steamboat Inspection Service. Both Lloyd's Register of Shipping and the American Bureau of Shipping have accepted electric resistance welded boiler tubes for both fire and water tube boilers.

A. W. S. Annual Meeting

THE AMERICAN WELDING SOCIETY has prepared a tentative program for the 17th annual meeting to be held in the Hotel Cleveland, Cleveland, O., Oct. 19-23. Among the papers of interest to power plant engineers are the following: "Fundamentals of Metallurgy of Welding," by E. S. Davenport and Dr. R. H. Aborn; "Multi-layer Oxyacetylene Pipe Welding," by R. M. Rooke, F. C. Saacke and A. N. Kugler; "X-Ray Methods of Studying Stress Relief," by John T. Norton; "Circuit Characteristics and Arc Stability," by S. C. Osborne; "Importance of Design Control for Welded Piping Systems," by T. W. Greene; "Principles of Surfacing by Welding," by E. W. P. Smith; "Technique for Resistance Welding Ferrous and Non-Ferrous Sheet Metals," by E. I. Larsen; "Procedures for Control of Welding Parts," by G. H. Moore, Jr.; "Resistance Welding of Dissimilar Metals," by R. T. Gillette; "Thermit Welding," by J. H. Deppeler; "The Exploration of the Modern Metallic Arc," by L. J. Larson.

During the time this meeting is in session there will be a Metal Congress Exposition at the Public Auditorium in Cleveland. Meetings have also been arranged by the American Society of Mechanical Engineers for Oct. 23, which will deal with a number of topics related to the welding field.

On Oct. 23, the two societies, A.W.S. and A.S.M.E. will hold joint sessions both in the morning and afternoon and in the evening there will be a dinner dance. The A.S.M.E. meeting will extend over to Oct. 24 and A.W.S. members are cordially invited to attend both sessions.

Freon Refrigeration Equipment

Some of the Characteristics That Must Be Considered When Using Freon

By L. S. MORSE*

COMPARISON of a few well known refrigerants at the A.S.R.E. standard ton conditions with respect to the theoretical displacement of the compressor and quantities of liquid refrigerant to be vaporized are given in Table I. For these standard ton conditions it is observed that Freon-12 has a low net refrigerating effect in B.t.u. per pound, being less than 11 per cent of that for ammonia, but the net cubic foot displacement per minute is only 69 per cent greater than that for ammonia. This is due to the greater density of "Freon-12" vapor, 1.485 cu. ft. per lb. at 5 deg. F., whereas ammonia is 8.15.

The differential operating pressures, 81.4 lb. per sq. in. for the standard conditions—seldom exceeds 100 lb. for service conditions with water cooled condensers. This is an important design consideration and permits larger diameter cylinders than are used for ammonia compression, without exceeding established unit bearing and stress values commonly used in compressor design.

Manufacturers may therefore embody a crankcase and shaft designed for an ammonia compressor, in a Freon-12 compressor which has larger diameter cylinders, all of which tends to mak a low productive cost per ton of refrigerating capacity. This cost is materially affected by the comparatively low net piston displacement per ton—5.815 cu. ft. at the standard conditions.

Characteristics of five commonly used refrigerants under standard ton conditions 5 deg. F. evaporator and 86 deg. F. condenser temperature

Refrigerant	Freon-12 CCl_2F_2	Carbon Dioxide CO_2	Ammonia NH_3	Methyl Chloride CH_3Cl	Sulfur Dioxide SO_2
Boiling Point Deg.F. at At. Pres.	-21.7	-108.4	-28.0	-10.6	14.0
Abs.Pres.,Lb.per sq.in. at 86 deg. F.	107.9	1039.0	169.8	95.55	66.45
Abs.Pres.,Lb.per sq.in. at 5 deg. F.	26.51	334.4	34.27	20.89	11.61
Heat Content,Saturated Vapor in 5 deg. F. Evaporator, B.t.u. per lb.	78.79	102.14	613.35	195.3	183.49
Heat Content of Liquid Leaving 86 deg.F. Condenser, B.t.u. per lb.	27.72	45.45	138.9	46.6	42.12
B.t.u. Refrigerating Effect per lb.	51.07	56.69	474.45	148.7	141.37
Lb. of Refrigerant per min. per ton of refrigeration	3.916	3.528	.422	1.345	1.414
Cu.ft. of liquid per lb. at 86 deg. F.	.012	.027	.027	.018	.012
Cu.in. of liquid per min. per ton of refrigeration	83.9	162.8	19.6	41.7	28.9
Cu.ft. of vapor per lb. at 5 deg. F.	1.485	.257	8.150	4.529	6.421
Cu.ft. of net piston Disp. per min. per ton of refrigeration	5.815	.943	3.436	6.091	9.084
B.t.u. Refrigeration per cu.ft. of piston displacement	34.4	212.0	58.2	38.8	22.0

*Executive Engineer, York Ice Mach. Corp. and President of the A.S.R.E. This is an abstract of a paper presented before the International Congress of Refrigeration, The Hague.

The calculated discharge temperature for standard tonnage conditions with superheated suction gas at 10 deg. F. is approximately 108 deg. F. For 35 lb. ga. suction pressure and 65 deg. F. temperature the calculated discharge temperature at 145 lb. ga. pressure would be about 178 deg. F., which is closely approached in actual practice.

Saturated Freon-12 vapor is approximately three to five times more dense than the other refrigerants listed, with the exception of carbon dioxide. Therefore the gas velocities through the suction and discharge valves of Freon-12 compressors must be sufficiently low in order to prevent excessive pressure drop and wire drawing which would materially reduce the operating efficiency. This requires not only correctly designed valve openings and port areas, but stream line flow or hydraulically contoured passages for the flow of the gas into and out of the compressor. In fact this precaution of minimum restriction to flow applies alike to mains, connections, shut-off valves, fittings, etc.

One of our large manufacturers states that acceptable velocities in "Freon-12" compressors are from 2500 to 3000 ft. per min. through the suction valve openings, based on the suction valve being open one-half a complete revolution; and from 3000 to 3500 ft. per min., through the discharge valve, based on the discharge valve opening after two-thirds of the compression stroke is completed; or one-third of the cylinder displacement must pass through the discharge valve in one-sixth of a revolution.

Without going into a technical discussion of all the factors entering into the proper size of piping to eliminate excessive pressure drop, let it again be stated that the weight, quantity, and other characteristics of Freon-12 require larger pipe mains than do the other refrigerants.

It is a well known fact that the capacity and efficiency of any refrigerating installation depends to a great extent in maintaining the minimum friction loss in the suction line between the evaporator and the compressor, hence particular attention should be given to the size and length of the suction main. The manufacturers of Freon-12 state, "The limits of Freon-12 vapor or gas velocity in feet per minute through the piping should be approximately as follows, although best results will be obtained when the velocities are reduced 20 per cent or more:

	Large Pipe Sizes	Small Tubing Sizes
Suction Line	2750 to 3750	800 to 1800
Discharge Line	3750 to 4750	1750 to 2250

"The limiting velocities of 'Freon-12' in liquid lines are between 80 and 200 ft. per min. dependent on size of pipe and tonnage."

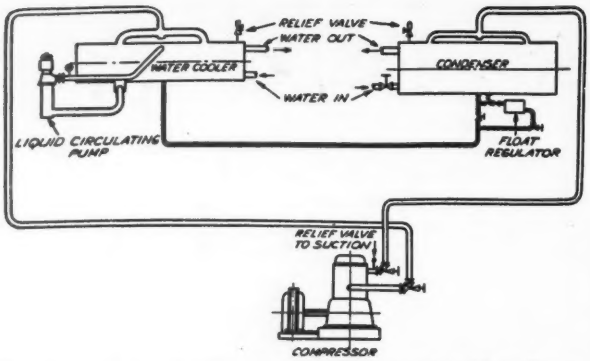


Fig. 2. A water cooler arrangement particularly adaptable to Freon

For small mechanical condensing units dehydrated copper tubing is generally used. Flared joints with soft annealed tubing are often used on 5/8 in. O.D. and smaller sizes, and soldered or brazed joints on the larger sizes. Shut-off valves are generally of the diaphragm packless type.

In these small installations it is advisable to furnish fine meshed screen filters in the liquid lines to prevent foreign matter from interfering with the action of the liquid control valves. For the larger installations scale free steel pipe is generally used with as few flanged joints as possible. This is accomplished by welding in the field not only the abutting lengths of pipe, but also steel elbows are welded to pipes. Whenever pipe flanges are used they may be welded. If threaded connections are used clean sharp close fitting threads are required and the joint made up with litharge and glycerine, or some other pipe compound unaffected by Freon-12 and oil.

In the design of condensers, evaporators and other heat transfer apparatus, consideration must be given other additional properties of Freon-12 such as, thermal conductivity and viscosity. The experience gained in laboratories and from actual field installations have led most manufacturers to furnish approximately twice as much condensing surface as for ammonia at the same mean temperature difference and tonnage.

Lubrication of a Freon-12 compressor is similar to that of any other compressor using a refrigerant, such as methyl chloride, which is completely miscible with mineral oil. A portion of the oil will eventually pass along from the compressor to the condenser and through the liquid line to the evaporator. In the small tube evaporator in which the liquid is fed in series we have a perfect continuous still concentrating oil which is carried along with the evaporated gas so there is no oil logging of the evaporator. However, in the flooded or spray type the still action leaves the oil behind, increasing the concentration in the evaporator to a point where the evaporating efficiency is impaired, requiring periodic purification. This is usually done by operating the evaporator as a "batch still" distilling off the Freon-12 and withdrawing the residual oil.

It is important that compressors and all other apparatus used in a Freon-12 refrigerating system be thoroughly cleaned of all dirt, scale and foreign matter, and every trace of oil, soldering flux and washing compounds should be removed. Freon-12 is a solvent and physically dissolves and loosens such foreign matter which otherwise would be carried along by the liquid and vapor and deposited at vital points, such as valve seats, if provision were not made for its interception. Therefore, filters with fine mesh screen of large area, designed for easy disassembly to permit cleaning of the screen, should be provided to protect the compressor and all automatic regulating valves.

In tubular evaporators used for cooling and conditioning flowing air the total length of the runs for the refrigerant must be such as to keep pressure drop to a reasonable figure. The designer decides on the maximum pressure drop the installation will stand and arranges the length of the refrigerant passage to suit. Figure 1 shows the arrangement of distributing heads placed between thermal expansion valves and coils, with sufficient distributing connections to each evaporator coil section to properly proportion the flow of refrigerant and to obtain the desired pressure drop through the section. Without such distributing head it would be necessary to use individual expansion valves to the various evaporator sections.

Many of the large air conditioning installations, due to the owner's preference or safety code restrictions, employ the indirect system, or one in which water is cooled by the refrigerant and the chilled water is circulated through coils or sprayed directly in the air washer for the purpose of cooling and conditioning the air. Fig. 2 shows diagrammatically an arrangement of the machinery and apparatus for a Freon-12 water cooling system. On account of the high cost of this refrigerant, the design aims to reduce to a minimum the refrigerant charge in the system. There is no accumulation of liquid in the condenser as it drains to the float regulator vessel located below the condenser. The float regulator, serving as an expansion valve, automatically discharges all liquid as condensed, to the shell and tube water cooler.

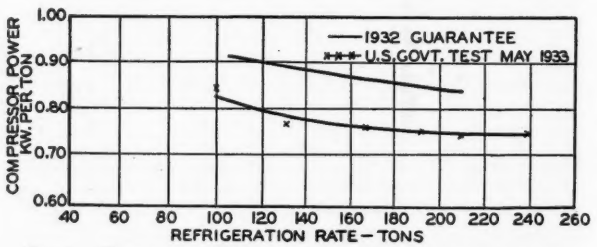


Fig. 3. Guarantees and test results on a 210 t. government air conditioning installation

Normal liquid level in the evaporator is below the bottom row of tubes. The liquid is circulated by means of a pump through a spray header inside the shell and above the top row of tubes. The quantity of liquid circulated is more than the liquid evaporated to make sure of sufficient and uniform sprayed liquid over the entire tube surface. The liquid which is not evaporated flows to the pump chamber, together with the liquid from the condenser, and is recirculated.

This type of evaporator for cooling water or brine, though applicable for any refrigerant, is particularly well adapted for Freon-12. The primary advantage is minimum charge and cost of refrigerant, a prime factor in the case of Freon-12. A secondary advantage gained from the spraying of liquid over the tubes instead of the commonly used flooded evaporator, is that the rate of heat transfer is materially increased.

Oil and Gas Power Division of the A.S.M.E. meets at the University of Michigan, Ann Arbor, June 24 to 27. Registration about 150

Oil Engine Men Review Progress

UNDER A TACIT, if unspoken, truce between the Diesel engine and utility men, the ninth National Oil and Gas Power meeting of the A.S.M.E. proceeded without the sometimes acrimonious discussion which, from time to time in the past, has lent color and animation to these meetings. Bereft of this, the Convention proceeded to an orderly consideration of detailed engine design and the problems which today confronts the designer largely as a result of the introduction of the high speed engine and changing fuels.

Most of these problems revolve around the phenomena of knock or detonation. Much progress has been made in the study and solution of these problems but discussions indicated that the problem is far from being solved to the satisfaction of all concerned, although the way now appears open to a final approach.

Pending theoretical solution of the problem, two lines of practical endeavor are being followed: First, engine designs giving a low maximum pressure; second, development of fuels which do not exhibit this phenomena. The second has been handicapped largely by lack of instruments and equipment necessary to give reproduceable tests in different laboratories and thus arrive at a satisfactory index of fuel quality. Under the direction of the Volunteer Group at least a partial solution is expected soon. The present status of fuel research was outlined by A. E. Becker, Standard Oil Development Co. and M. J. Reid, Diesel Engine Manufacturers' Association.

From the standpoint of design, progress has been satisfactory. N. Fodor, Allis-Chalmers Mfg. Co., described a fuel injection spark ignition engine designed primarily for tractor service and to be interchangeable both in the tractor and assembly line. It burns all types of commercial fuels with considerable economy over the gasoline engine and develops but moderate maximum pressure.

Shaft Design

Characteristics of the Lanova combustion system, which utilizes an 8-shaped combustion chamber and auxiliary air chamber for turbulence, were outlined by Hans Fischer of the Lanova Corp. The efficiency of the system in reducing maximum pressures in the main chamber were demonstrated by means of indicator cards, some of them taken from a Buda high speed engine which utilizes this combustion system.

Just what effect high gas pressures have on crank shaft and bearing design seems subject to considerable difference of opinion. Crank shafts are ordinarily designed according to the demands of tortional vibration while gasoline engine practice has shown that inertia is a controlling factor at high speed so that high gas pressure stresses are satisfactorily taken care of by shafts designed in accordance with the other two factors.

Almost unbelievable deflection of short length of very stiff shafts were recorded by Harte Cooke, McIntosh & Seymour Corp., in a paper giving the results of wear in a large steam engine bearing in service for many years. This 18 in. diameter bearing was worn in an hour-glass shape with a maximum deflection in diameter of something life half an inch between the waist and the outer edges. This was cited as confirming the validity of the trend toward narrower bearings primarily in an endeavor to get stiffer shafts.

Governing

Speed regulation and parallel operation are assuming increased importance and was the subject of three papers. Engine Governors by G. C. Wilson, University of Michigan, and the Characteristics of Internal Combustion Engine Drive A. C. Generators for Parallel Operation by W. T. Berkshire and R. H. Kaufmann, General Electric Co., were both highly theoretical papers which precluded detailed discussion, although the point was brought out that engine plants seldom if ever justify the expense of automatic frequency control. Manual regulation from a spring driven or electric master clock operated on the utility system usually suffices even when clock or close process operation is involved.

The third paper on this subject dealt with the characteristics of fuel injection systems and was delivered by C. R. Alden, Excello Aircraft and Tool Co. Theoretical and practical aspects of injection equipment and the effect of governing were discussed and a new combination governor developed by his company was described. Centrifugal governing gives good regulation for high speed but its efficiency falls off at low loads while pneumatic governing from the air intake manifold pressure has the opposite characteristic. These two methods have been combined in a single

governor so as to take advantage of the most effective range of both.

Lubricating oils, like fuels, are still in the debatable stage and were discussed at some length by C. M. Larson, Sinclair Refining Co., from the standpoint of performance based on service conditions. Many factors have been considered as an index of the suitability of an oil for lubricating purposes but it was the opinion of the author that in operation a maximum of 2 per cent sludge is all that should be allowed.

Vibration, inherent in any piece of rotating machinery, may be isolated by properly constructed foundations and bases as outlined by S. Rosenzweig, Korfund Co., Inc. Relative advantages, proper application of various isolating materials were pointed out and different types of vibration dampers, including natural cork and steel springs for machines with and without concrete foundations were discussed in detail.

Railroad Service

From a background of almost 40 yr. experience with motor trains, E. F. Weber of the Burlington Lines, discussed the application of Diesels to this service and came to the conclusion that they have a definite place in the railroad field. The latest venture of this company is a 10 car train, with two main and four auxiliary engines. Three of the later are operated in parallel and are synchronized automatically by General Electric control equipment.

This year's report of the Diesel Power Cost Committee covered 168 plants and represented a total power output of over 3,000,000 kw-hr. In the absence of the committee chairman, H. C. Major, Commissioner of Public Utilities, Rockville Center, the report was presented by M. J. Reid, secretary of the Diesel Engine Manufacturers' Association. As usual, some discussion developed over minor points in the calculation and the method of use but there was no question but that the constantly increasing scope of the report makes it of inestimable value to the industry.

Diesel Training

Diesel engine training, a relatively new problem, is assuming increasing importance and F. G. Hechler of Pennsylvania State College presented the results of a questionnaire to colleges and-techical schools in the United States and Canada. The majority of these schools give Diesel instructions in one form or another but the author reached the conclusion that it "seems inevitable that the Diesel engine does not open up a vast new field of employment either in manufacturing, operating and servicing and that the rate of pay is not substantially greater than in other similar lines of work."

The convention was welcomed to the University by H. C. Sadler, dean, College of Engineering, in the opening session, presided over by Lee Schneitter, Ebisco Services, Inc. Following this some of the research activities of the University were outlined by Professors A. E. White and C. W. Good. An inspection trip was then made through the numerous laboratories of the University, not the least important item of interest being the new Cyclatron, one of the seven now being built or under construction in this country and another notable step in man's study of the atom. Professor Lawrence, University of California, who developed the Cyclatron, conducted a seminar at the University during the month of July.

General Motors Research Pictures

At an informal dinner on the first evening of the conference, W. L. Batt, president of the A.S.M.E., spoke highly of the professional division's activities and paid a particular compliment to the splendid organization of the Oil and Gas Power Section. At the banquet two evenings later, E. Blythe Stason, Professor of Law, discussed what he considered some of the limitations and industrial effects of the Federal Security Act. Following this, the General Motors Corp. presented a special research film showing moving pictures of combustion in an engine cylinder taken through a quartz window at the rate of from 2500 to 5000 frames per second. These pictures which showed clearly the differences between normal and knock conditions in the cylinder have been shown widely throughout the country and represent an important step in the perfection of internal combustion engine.

Air Conditioning The Queen Mary

FIVE INDEPENDENT air conditioning plants, comprising supply and exhaust fans, dehumidifiers, steam heaters, automatic air dampers, temperature and humidity controlling equipment, are installed aboard the Cunard White Star superliner, Queen Mary. These equipments, Carrier design, have a combined capacity of nearly 7,000,000 cu. ft. per hr. and serve the main dining saloon, four private dining rooms, tourist dining saloon, main lounge and main beauty parlor. They are designed to take care of conditions ranging from 0 deg. F. in winter to 100 deg. F. in summer with every possible variation in humidity.

Three sources of refrigeration are included in the complete equipment. The largest part of the refrigeration effect is provided by means of a steam ejector type water cooler which is located in the aft auxiliary generator room. Refrigeration for the tourist saloon is supplied by one of the standby CO_2 plants forming a part of the stores refrigerating system. The beauty parlor has an independent methyl chloride refrigerating machine located alongside the air conditioning plant and near the space served.

Refrigeration for all the larger plants is distributed by means of chilled water which is sprayed in the various dehumidifiers. In the case of the tourists saloon this water is cooled in the CO_2 evaporator. The refrigerated water for the plants serving the main and private dining saloons and lounge is cooled from the steam ejector water cooler. In order to facilitate the operation of the plants, pneumatically operated automatic controls are provided working from thermostats in the air conditioned spaces and on the various plants. All the fans associated with the installation have direct-coupled driving motors and are generally provided with speed control.

Third World Power Conference

TO BE HELD in Washington, D. C., Sept. 7 to 12, in conjunction with the Second International Congress on Large Dams, the Third World Power Conference will deal, as previously pointed out, with the economics and social significance of the utilization of material resources,—water, fuel, oil and gas,—for generation of power, the conservation of those resources and with systems of generation of power and distribution to consumers. On topics on which there are differences of opinion as to policy, the endeavor has been to have papers presented by representatives of the several lines of thought and the names of authors whould seem to indicate that the presentations will be carefully made.

Official headquarters will be at the Mayflower Hotel and meetings will be held in the auditoriums of government buildings along Constitution Avenue.

Monday evening, Sept. 7, the formal opening session will be held. Tuesday morning sessions will deal with production and distribution of Coal and Petroleum; and for the Congress on Dams with Design of Joints. Tuesday afternoon Trends in Development and Utilization of Power Resources will be taken up; also Facing of Dams. Wednesday morning the topics will be Production and Distribution of Natural and Manufactured Gas, also Organization of Private Electric and Gas Utilities; and Special Cement for Dams. Wednesday afternoon session will deal with Collection and Use of Statistics, also Public Regulation of Utilities; and with Foundation Materials for Dams. Thursday morning will be given up to Organization, Financing and Operation of Publicly Owned Utilities, also Conservation of Coal, Petroleum and Natural Gas Resources. Thursday afternoon the session will take up National and Regional Planning with Relation to Conservation of Natural Resources; and Stability of Earth Dams. Friday morning, Planned Utilization of Water Resources, and Regional Integration of Electric and Gas Facilities will be presented; and an executive meeting of the Congress on Dams. Friday afternoon the topics will be Utilization of Small Waterpowers, also Rationalization of Distribution of Electric Energy and Gas, including Rural Electrification. Saturday morning will be given to National Power and Resources Policies. Saturday afternoon will be a closing meeting of the Conference and the Congress.

Morning sessions will be at 10 o'clock; afternoon sessions at 2 o'clock. At the Washington sessions papers will be followed by open discussion, but propaganda and politics are barred.

The Washington sessions will not take up technical details, but before and following the Conference a series of tours will be arranged, each lasting from 6 to 10 days, to visit power developments in various parts of the country, including the principal cities, Tennessee Valley, and other water power developments east of the Mississippi River. The inspection trips will be supplemented by round table discussions dealing with the technical problems of the plants visited. Also a transcontinental tour of 3 weeks by special train is being planned to cover Canadian points, Grand Coulee, Pacific Coast plants and Boulder Dam. Details of itinerary and cost of the tours can be obtained from the American National Committee, Interior Building, Washington, D. C.

The Technical Tours will be held both before and after the Conference sessions in Washington, where more than 700 distinguished foreigners, representatives of 48 nations, will meet with some 2500 Americans for a week's sessions, devoted to a consideration of "The National Power Economy."

Those participating will inspect hydro power plants, research laboratories, electrical manufacturing plants, business offices of urban utilities, metropolitan railroad terminals, big dams and small dams, high speed railroad trains in operation and under construction.

The following points are included on the tour itineraries:

Tour I: Pre-Conference, New York, Detroit, Cleveland and Pittsburgh; Post-Conference, New York, Pittsburgh, Cleveland, Niagara Falls, and Philadelphia.

Tour II: Pre-Conference, New York, Boston, Niagara Falls, Pittsburgh, Zanesville, Ohio, Knoxville, and other points in the Tennessee Valley; Post-Conference, New York, Montreal, Ottawa, Niagara Falls, Pittsburgh, Zanesville, and the Tennessee Valley.

Tour III: Pre-Conference, New York, Schenectady, Chicago, and Pittsburgh; Post-Conference, New York, Schenectady, Niagara Falls, Chicago, Pittsburgh and Philadelphia.

Tour IV: Pre-Conference, New York, Schenectady, Chicago, and Pittsburgh; Post-Conference, New York, Schenectady, Niagara Falls, Chicago, Pittsburgh, Philadelphia.

Tour V: New York, Montreal, Ottawa, Niagara Falls, Chicago, Ft. Peck Dam, Grand Coulee, Seattle, Portland, San Francisco, Los Angeles, Boulder Dam, Knoxville, and the Tennessee Valley.

There will be a comprehensive exhibit illustrating by photographs, models, charts and moving pictures the development of power production and distribution. Also excursions will be arranged, to suit the convenience of visitors, to see the noted features of Washington and its surrounding territory. Social events will include a formal banquet to delegates and members of the Conference, teas, garden parties and receptions.

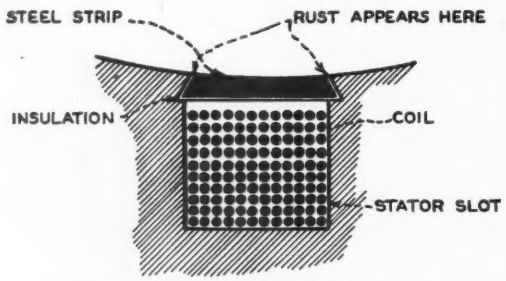
Registration fee, as a member of the Conference, will be $10 which covers admission to all sessions, participation in all local excursions without cost and participation in social functions with or without additional cost as may be provded. Wife or lady accompanying a delegate or registered member will have the same privileges as the member without payment of any registration fee.

Formal dress will be in order at the opening session on Monday evening, Sept. 7, and at the formal banquet, the evening of Sept. 10. At all other times informal dress will be in order and light summer clothing will be most comfortable.

Readers' Conference

Rust Indicates Looseness

ORDINARY IRON RUST at any particular point in a laminated structure indicates that some vibration or movement has taken place. For instance, on certain types of motors a small steel strip is wedged into the stator slot to hold the coils in place. This construction is shown in the accompanying sketch. Sometimes the insulating material between the strip and the laminations deteriorates and allows the strip to work loose. When this is the case the laminations show a streak of



Rust often indicates hidden vibration

rust along the edges. It is possible by inspection to determine if any of the strips are loosening up and sometimes the loosening will be so slight that it can not be felt by the fingers. In a like manner a shaft which is loose in a laminated rotor of a motor can always be spotted by the rust appearing on the laminations near the shaft. Probably the lacquer on the laminations is loosened and cracked by the vibration when the motor is running thus allowing the metal to rust.

Sayerville, N. J. K. B. HUMPHREY.

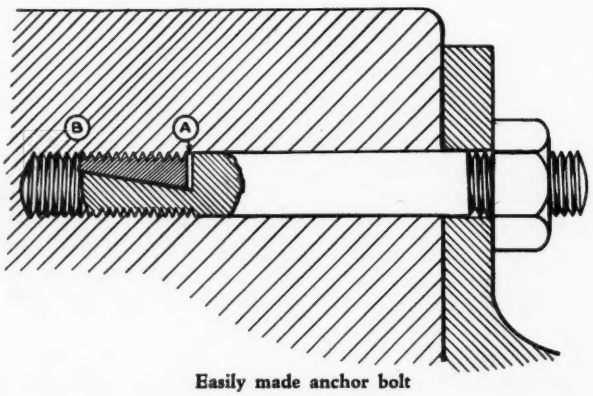
Red Powder Around Loose Keys

IN THE JUNE issue Mr. W. E. Warner speaks of the dull red powder which accumulates around loose keys, etc., and ascribes it to abrasion from the key when first installed which later oxidizes. There was a very interesting article in a recent issue of Mechanical Engineering on quantitative measurement of cutting or "galling" of metal surfaces in contact and subject to relative motion. In this the author mentioned this phenomenon and showed that the red powder is iron oxide which forms because the metal abraded by the slight relative motion of the parts is so finely divided that it oxidizes at once and that the phenomenon continues as long as there is this motion. In fact, one of the best indications that a pulley is "working" on a shaft is the presence of a small amount of red dust, which occurs before any looseness is otherwise noticeable.

New Haven, Conn. H. D. FISHER.

Simple Sure Anchor Bolt

OFTEN THE need of an anchor bolt is at hand and none of the commercial type are available or time does not permit waiting for one, on such an occasion a simple bolt can easily be made as shown in the sketch and will be found to be very practicable. It has the advantage of cheapness being made from a regular machine bolt or stud.



Easily made anchor bolt

While the sketch is self explanatory, it may be well to describe it. After selecting the right length and size bolt a cut is made with a hack saw as at A to about half the diameter of the bolt then starting at the end B a slanting cut is made to meet the one at A this gives a taper section as shown and when the bolt is placed in the hole to be anchored the action is that shown in the sketch.

Concord, N. H. C. H. WILLEY.

Blowing Down Water Columns

AN ARTICLE on gage glasses appeared on page 310, May issue, Power Plant Engineering. One point in this article states that too frequent blowing down of the water column and gage glass connections is not advisable. The important part is, just what is meant by "too frequent." Every hour would usually be too frequent, but every day most certainly is not. Many state operating codes advocate blowing down the lower connections of the water columns and gage glasses once every 8 hr. of operation. Others say not less than once a day.

Just why should these connections be blown down at all? If this is understood, the time element becomes a matter of common sense. Let us assume that we have a boiler taking feedwater from a river. The time is just after a heavy rain, and concentration of silt and suspended solids is very high. Going a step further, let us suppose that either there is no filtra-

tion installation at this plant, or that if there is one, it has become defective. The immediate result—concentration of solids in the boiler goes to a high value unless exceptional care is exercised in blowing down the boiler. Sludge settles out wherever there is sluggish circulation, especially favoring the lower connections to water columns. A slightly less rapid but equally effective cause of this same condition will be found with certain feedwater treatments which precipitate carbonates and sulphates from the boiler water.

As soon as the lower connection to the water column becomes obstructed, the gage glass shows a false water level. The obstruction will keep the water in the column and glass from falling, even though the water in the boiler goes to a dangerously low level. Many serious accidents have resulted from this cause. I have found that in many boilers where practice has been to blow down these connections infrequently—say once a week—the lower connecting pipe to the water column was almost completely filled with sludge, especially on the horizontal runs. Any unusual operating condition, as those mentioned, would be enough to complete the obstruction and create a hazardous condition.

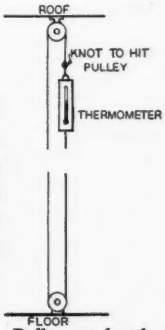
Blow down those water columns at least every day of operation to be on the safe side.

Flushing, N. Y. HARRY M. SPRING.

Bringing the Thermometer to Earth

IN AN ICE STORAGE a ladder was used to read a thermometer which was 65 ft. high. The need for this ladder was eliminated by using two awning pulleys and some sash cord to lower and raise the thermometer. This required little effort and the accident risk was eliminated.

Cleveland, Ohio. FRED W. SCHNEIDER.

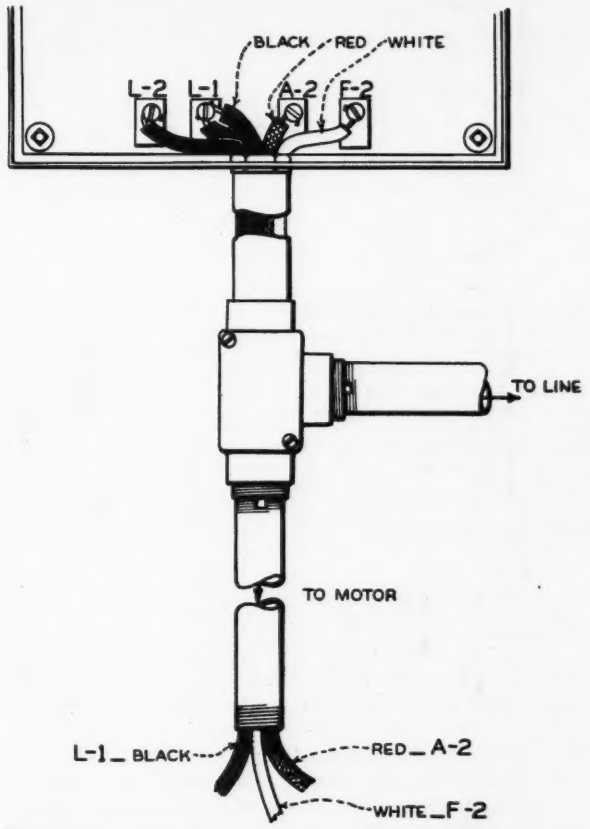


Pulleys and sash cord aid thermometer reading

Color Code in Wiring Motors

IF A CERTAIN CODE OF WIRING connections were followed when hooking up lines to direct current motors, the connecting and disconnecting of motors for repairs would be simplified. Also, testing of wiring between the starting rheostat and the motor terminals for continuity and grounds would be made easier. Mixups in the reconnecting of direct current motors would be lessened by adopting this plan.

The plan or code consists merely of using certain colors of wire for each of the three wires usually run between the starting rheostat and the direct current motor. A suggested code is shown in the accompanying sketch. In the sketch, a black wire connects L-1 terminal on the starting rheostat with the A-1 and F-1 terminals on the motor. A red wire is run between the rheostat terminal A-2 and the motor terminal A-2. A white wire leads from the rheostat terminal F-2 to the F-2 terminal on the motor.



Baltimore, Md. THOMAS TRAIL.

Which Direction Does Current Flow in a Current?

IN READING A. W. Kramer's articles on electron tubes, I note that he states that the plate or anode of the tube is positive, and, I take it, that this is so because it is connected to the positive terminal of the battery. If this is so, should not the current flow from the plate to the cathode, rather than from the cathode to the plate? How is it possible for the electrons to be drawn to the plate and flow through the external circuit back to the cathode against the current from the battery?

Also, I note that the direction of the current in the circuit in Fig. 11 (April issue, p. 233) is in a direction that would oppose a positive current to the plate. And, in the case of Fig. 2 (April issue, p. 231) would any current flow from the plate battery? If so, in what direction?

CHARLES MORRISON.

A. It is quite apparent, judging from Mr. Morrison's questions that he did not read the first article of this series on electron tubes, for these matters were explained, though rather briefly, at the end of that article. We are, however, glad to have the opportunity of explaining this question regarding direction of current in greater detail, for the confusion which exists in Mr. Morrison's mind is a common one and is a natural consequence of the system of education in this respect

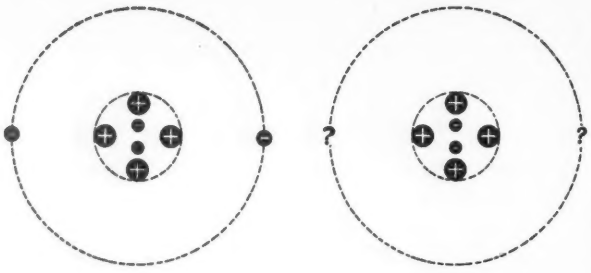


FIG. 1 FIG. 2

Fig. 1. Conventional diagram of a neutral Helium atom. It consists of a nucleus composed of four positively charged elements called protons and two negatively charged elements called electrons. These six elements are disposed in a small but densely compact mass, and since there are two more protons than electrons, the nucleus as a whole exhibits a positive charge. This positive charge, however, is compensated for by two external electrons travelling in a closed orbit, some distance from the nucleus. The atom as a whole, therefore, is electrically neutral.

Fig. 2. Here the two external electrons have been stripped from the stem, hence it exhibits a positive charge and will tend to attract any negative charge that may happen to come within range of its field.

to which he, in common with many others have been exposed.

Nearly all of us were taught, in school and in the field, that the flow of electricity in a circuit was always from the positive to the negative terminal. In fact, the very term *positive* denoted a condition which was higher than negative. This conception of the flow of electricity in circuits, however, was not based on absolute knowledge. It was formulated before the advent of the electron theory and was nothing more than an arbitrary assumption. Indeed, fundamentally, the terms "positive" and "negative" with reference to electricity had really no absolute meaning; they merely implied a difference.

As was stated at the end of Part I of the series of articles on Electron Tubes now appearing in these pages (page 119, February issue), "the pioneer electrical experimenters had no knowledge of the electron theory and therefore no real understanding of the nature of an electric current. Hence, they arbitrarily assumed the direction of current to be from positive to negative. They had just a 50-50 chance of being right, but, unfortunately, as now disclosed by the electron theory, they chose wrongly."

Today, according to accepted theory, and as indicated by experiment, an electric current really consists of a flow of electrons,—not a rapid movement as one might be inclined to infer, but a very gradual movement—really a slow drift of free electrons traveling always toward the positive terminal of the circuit.

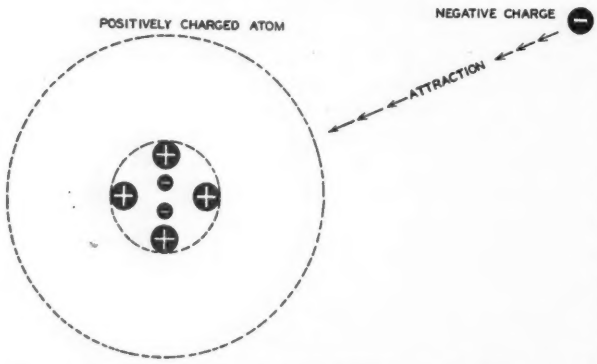


Fig. 3. Here a free electron is being drawn towards the positively charged atom. The ionized atom is very much more massive (some 1800 times) than the electron, hence the electron moves towards the atom. This represents an electric current.

To go back to fundamentals, consider a neutral atom as shown in Fig. 1. This represents a neutral Helium atom, but any other atom would do as well. We have chosen the Helium atom because of its fundamental simplicity. It consists, simply, of a central nucleus made up of four positively charged elements called protons and two negatively charged elements called electrons. These six elements are disposed in a closely compacted mass. Since there are two more protons than electrons, the nucleus considered as a unit has an excess positive charge of two. This unbalance, however, is compensated for by two external electrons traveling in a closed orbit at a distance from the nucleus.

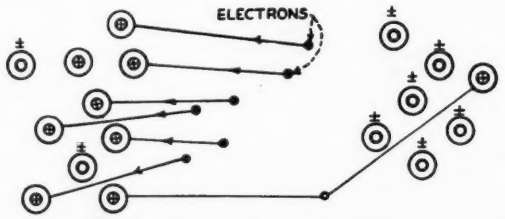


Fig. 4. If a number of positively charged atoms are grouped in one region and a number of free electrons are present, the electrons will be drawn towards the positive charges. This represents a stronger current.

Suppose now, that by some means or other we remove both of these external electrons as indicated in Fig. 2. It is evident that the atom as a whole will be left unbalanced, that is, it has one more positive charge than it has negative charges. In this condition it is unsatisfied and will tend to attract any electron that happens to come close to it. Under these conditions the electron is said to be ionized or, specifically, that it carries a positive charge.

If an electron, E_1, exists some distance away from the positively charged atom, as shown in Fig. 3, it will be drawn to the atom since unlike charges attract. This movement of the electron towards the charged atom is really an electric current, the smallest possible electric current in fact, but note that it flows toward the positive charge.

If, instead of just a single positively charged electron a number of them are grouped in one region and a number of free electrons are present as suggested in Fig. 4, all the electrons will be drawn towards the positive charges. This represents a stronger current.

In the same way the countless billions of free electrons in a conductor flow toward the positive terminal in the circuit. The principle is exactly the same. Of course, one might argue that if a negative electron is attracted to a positively charged atom so also is a positively charged proton attracted to a negatively charged atom and, therefore, an electric current might consist of a stream of protons moving toward the negative terminal of the circuit.

In liquid conduction, and to some extent in gaseous conduction, this is actually a fact. There is a translation of positive ions toward the negative terminal.

This is often the case in electron tubes. In solid conductors, however, the energy is transmitted entirely by the movement of electrons. The electron, it must be remembered, is some 1800 times less massive than the proton and so it travels faster and more easily than the proton. Furthermore, there are no free protons in the same sense that there are free electrons in a solid conductor so the transfer must be by means of electrons.

This general discussion, we believe, answers Mr. Morrison's questions. As we pointed out, it is unfortunate that those who formulated the early rules of electricity should have chosen wrongly in this respect for the convention persists to this day. In view of present knowledge this convention should be abandoned since it is extremely confusing when dealing with electron tube circuits. In all electric circuits, the direction of current is from negative to positive, not from positive to negative as most of us learned in school or elsewhere.

Electron Tube Questions

Q. WILL YOU KINDLY answer the following questions dealing with the testing of electron tubes?

1. Kindly sketch a circuit for testing an amplifier tube with the following elements: Filament, cathode, control grid, screen grid and plate, and also indicate the instruments that are necessary.

2. In testing does it make any difference whether a.c. or d.c. is used in the filament circuit?

3. Does the filament emit any electrons?

4. What information do we need to know whether a tube is good or bad?

5. If the filament current and voltage is maintained constant does the cathode emission remain constant during the life of the tube?

6. What is it that fails in a tube even though the filament lights up?

7. If the plate voltage is steady will the plate current be steady?

8. Why must the grid always be negative? Also the cathode?

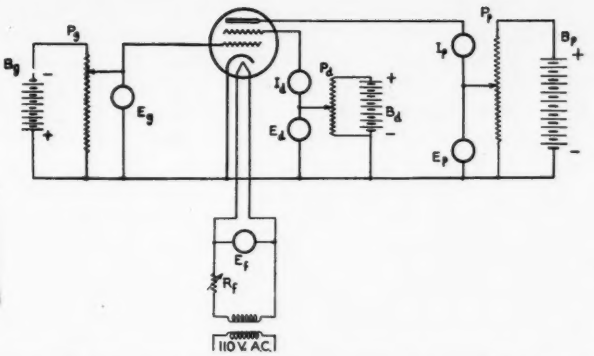
9. What is the polarity of the screen grid?

10. Can a testing outfit used to test amplifier tubes also be used to test rectifier tubes? Will it also be suitable for testing a "power" tube having only grid, plate and filament?

Millers Falls, Mass. M. H. M.

A.—1. In the accompanying diagram is shown a circuit which contains the essential elements necessary in testing a tube of the type described, that is, an indirectly heated screen grid tube. This circuit, as will be noted, has separate voltage supplies for the filament or heater, the control grid circuit, the screen grid circuit and the plate circuit. Each of these voltages, with the exception of that across the heater is variable by means of potentiometers. The voltage across the heater is varied by means of the heater rheostat R_f.

Each of these four circuits has a volt meter across it so that the voltage impressed upon the respective circuits can be accurately measured. In addition, the screen grid circuit and the plate circuit are also provided with ammeters so that the currents flowing in these circuits can be determined.



CONVENTIONAL TEST CIRCUIT FOR ELECTRON TUBES

E_g = grid voltmeter (0-50 v. d.c.)
E_f = filament voltmeter (0-10 v. a.c.)
E_d = screen grid voltmeter (0-250 v. d.c.)
I_d = screen grid ammeter (0-10 milliamp. d.c.)
I_p = plate ammeter (0-100 milliamp. d.c.)
E_p = plate voltmeter (0-500 v. d.c.)
P_g = grid cct. potentiometer 2500 ohms, 0.3 amp.
P_d = potentiometer—2500 ohm 0.3 amp.
P_p = plate cct. potentiometer 6500 ohms, 0.3 amp.
B_g = grid battery (60 v.)
B_d = screen grid battery (180 v.)
B_p = plate battery (400 v.)
R_f = filament rheostat (6 ohms, 5 amp.)

2. In this circuit the filament current is supplied by a step down transformer reducing the 110-v. a.c. supply to approximately 10 volts. With a tube of this type it makes no difference whether a.c. or d.c. is used in the filament circuit inasmuch as the cathode is indirectly heated and the variations in voltage of the filament supply cannot be transmitted to the plate or grid currents.

3. You ask whether the filament emits any electrons. Any incandescent filament tends to emit electrons but in this case the filament or heater element is entirely surrounded by the cathode and whatever electron emission there might be from the filament, it would have absolutely no effect upon any of the tube characteristics. In a tube of this kind the only function of the filament is to heat the cathode so as to cause it to emit electrons.

4. In testing a tube of this type in a circuit such as we have shown, the purpose is to determine how the plate current varies under the application of various grid and screen grid voltages, assuming, of course, that the proper plate voltage is impressed across the tube. Every tube, of course, possesses certain definite characteristics and the purpose of any test is to determine whether the tube meets these characteristics or not.

5. You ask whether the cathode emission remains constant during the life of the tube if the filament current and voltage are kept constant. In an ideal tube the answer to this question of course would be "yes", but in practice the cathode emission probably would decrease very slowly as the tube approaches the end of its life, due to the fact that the cathode surface would gradually become deactivated and under the continual action of heat would tend to disintegrate. For all practical purposes, however, you may assume that the cathode emission remains constant.

6. When a tube fails, even though the filament is still in good condition, a number of things may have taken place. First, of course, the cathode surface may have become deactivated. Cathodes, as you probably know, are composed of certain rare elements such as thorium which produce copious electron emission at comparatively low temperatures. As electrons are emitted new electrons are brought to the surface which in turn are emitted. There comes a time, however, when the material becomes deactivated and then in order to maintain the same electron emission, the temperature will have to be raised. Ultimately, of course, even this expedient fails.

Another thing that might happen to a tube is that the gas conditions within the tube may be changed. Ordinarily such a tube as we have under consideration is of the high vacuum type, containing relatively few molecules of gas. Under continual operation occluded gas may be liberated from the solid portions of the tube causing the gas pressure in the tube to change. This would change the characteristics of the tube and in some cases cause the tube to fail entirely.

7. Will the plate current be steady if the plate voltage is steady? Assuming that no changes are made in the grid voltage or the screen grid voltage and that the filament temperature is kept constant, the plate current should remain steady with a fixed plate voltage.

8. Why must the grid and the cathode always be negative? It is not true that the grid must always be negative, although this *is* true of the cathode. The very nature of the thermionic electric tube demands that the cathode be negative. Electrons, as you probably know, are negatively charged electrical particles and it is by virtue of this negative charge that they are attracted to other elements of the tube having positive charges or at least less negative charges than the cathode. The potential of the grid usually is maintained at a negative potential by a battery or by the voltage across the resistor in order to keep the plate current at a certain minimum value, or in many cases, to cut the plate current out or off entirely.

In operation, however, when alternating current potentials are applied to the grid circuit the grid may swing positive at least during certain portions of the alternating current cycle. During the times of such positive swings, the grid aids the plate in drawing electrons across the tube and increases the plate current.

9. With regard to the screen grid, this is usually maintained at a positive polarity at a potential somewhat lower than the plate potential. The potential applied to the screen, however, depends entirely upon what the tube is used for and sometimes the potential applied to the screen is higher than that applied to the plate. This is particularly the case when the tube is used as a dynatron.

10. Any good tube testing equipment that will test amplifier tubes of the type we have described here or other types can also be used to test rectifier tubes. Rectifier tubes usually are merely two element tubes consisting of a filament acting as a cathode and a plate which, of course, is the anode. The same circuit can also be used to test power tubes which have only filament, grid and plate elements. "Power" tubes, structurally, are no different from other tubes except that the elements may be more rugged. Whether a tube is used as a "power" amplifier, or as a "voltage" or "current" amplifier depends to a great extent upon the load resistance into which the tube works.

Cleaning Belts

IN THE MAY number of Power Plant Engineering, page 312, W. E. Warner recommends the use of superheated steam for cleaning conveyor belts in an article entitled, "Cleaning Conveyor Belts."

He does not mention, however, that the utmost caution must always be exercised in the use of steam for cleaning belting, particularly when the steam is superheated. Steam is an excellent cleanser for many purposes, that is true, but it must be remembered that many kinds of conveyor belting cannot withstand the high temperatures that go with steam. The temperature of dry saturated steam at atmospheric pressure is 212 deg. F. The higher the steam pressure the higher the corresponding temperature and when superheated it is even worse.

For most rubber belting, 212 deg. F. is too hot. One prominent rubber belt manufacturer states that his belting is not affected by heat up to a temperature of 200 deg. F. He states that where higher temperatures are to be encountered he should first be consulted. That is good advice regardless of the kind of belt. Even where steel chains are used one must be careful in high temperatures or lubrication difficulties will be experienced. Of course steel chains can be cleaned safely with steam and so can conveyor belts that are made of wire, as some of them are, and also those that are made of steel.

Balata conveyor belting is even more sensitive to high temperatures than rubber. Its temperature should be kept down to less than 110 deg. F. At 125 deg. balata gum can be moulded.

According to one well known authority on the subject, oak tanned leather, sometimes used for conveying, should not be subjected to a temperature higher than 115 deg. F., which means, of course, that oak belting should never be cleaned with steam. It can't stand it.

Impregnated cotton conveyor belting should never be cleaned with steam because the steam will very likely wash out the impregnated compound. Without the compound cotton belting does not give satisfactory results. Stitched canvas belting should not be used in temperatures higher than 140 deg. F.

So for these several reasons, as already stated, the utmost caution must always be exercised in cleaning conveyor belts with steam.

Newark, N. J. W. F. SCHAPHORST.

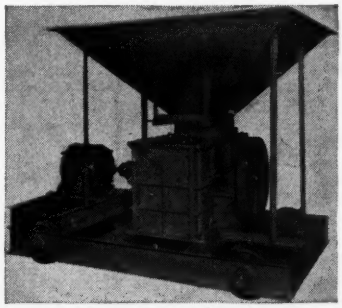
In the Movies

EXTENT of the use of power in making moving pictures is indicated by the 500 kw. for house lighting and 5500 kw. for stage lighting at the Denham Studios in England. Six 8-cylinder Diesel engines are used, of 1250 hp. each at 250 r.p.m., each driving a 750 kw. direct-current generator with 25 per cent overload capacity. Current is generated at 250 volts.

New Equipment

Portable Ring Crusher

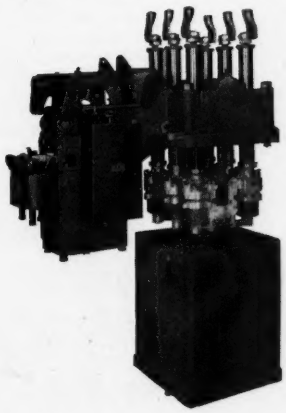
AMERICAN PULVERIZER CO., St. Louis, recently furnished a portable ring coal crusher to the Fort Dodge Gas and Electric Co., at Davenport, Iowa, to meet special requirements. This crusher, shown herewith, is a ring type crusher mounted



on a portable carriage of standard gage railway track. The purpose of the crusher is to reduce bituminous coal to smaller uniform size for their pulverizer. At times this company is unable to obtain Iowa screenings in size less than 1¼ in. This size, of course, is too large to work out satisfactorily with their pulverizer. The coal is fed to the crusher from a grab bucket, which is operated from a locomotive crane. The crusher has a large hopper. It is capable of reducing 30 to 40 t.p.hr. of 2-in. and under Iowa coal screenings to a product ¾ in. and under. It is also capable of handling larger coal, for instance, run of mine 8 in. and under. The crusher is direct connected to a 25 hp. 1200 r.p.m. motor.

Indoor Oil Circuit Breaker

A NEW INDOOR STATION type oil circuit breaker, type DZ-40, has been announced by Condit Electrical Mfg. Corp., Boston, Mass. It is equipped with interrupting devices called Ruptors, which it is claimed give quick-clearing of short circuits along with low arc energy, low pressure and a minimum of oil deterioration. Other features claimed for this equipment are: enclosed low inertia, high speed mechanism; internal shock absorbers; silvered contacts; oil and gas separator and Bakelain bushings.



It is furnished for 600 and 1200 amp. at 15 kv. and 2000 amp. at 7.5 kv. Interrupting capacity rating is 100,000 kv-a.

Ideal Electric Marker

THE IDEAL ELECTRIC MARKER, a new and inexpensive portable tool, for marking on practically any material, whether metal or non-conductor, is announced by the Ideal Commutator Dresser Co., Sycamore, Illinois. Legible and permanent records can be quickly, easily and safely made on all metals and their alloys; on dies, tools, plates, sheets, shapes, rods, forgings, cast-

ings, pipes, equipment; and also, on glass, pottery, ceramics, hard rubber, bakelite, plastics, fibre and similar materials.

The marker operates on 110 v. 60 cycle a.c. and consumes approximately 75 watts. It can, also, be furnished for other standard voltages and frequencies. The unit comes complete and ready to use, has a six-foot cord with plug and on-off switch.

Interchangeable Switchgear

DELTA-STAR ELECTRIC COMPANY, Chicago, Illinois, have developed a fully interchangeable Metal-Clad Switchgear for quick installation in as many sections as desired.

The steel enclosed sections are mounted along side of each other, and the main insulated busses are joined by bus sections as pictured. The two units shown are part of a six unit 4150 v. feeder installation. Each section is equipped with a manually operated oil circuit breaker, ammeter, watthour meter and overload relays. Each section is 7 ft. 0 in. high, 5 ft. 0 in. deep and 2 ft. 2 in. wide.

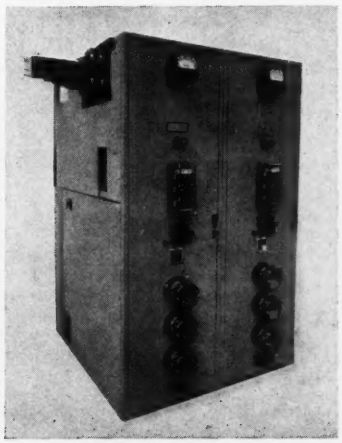


Photo-Cell Control

A NEW PHOTO-ELECTRIC CONTROL unit in which sensitivity and operating speed have been doubled, and which is said to be highly dependable even under difficult service conditions, has been introduced by the Weston Electrical Instrument Corp., Newark, N. J.

The assembly consists of a Weston photo-cell of high output characteristics in a protective mounting, the complete relay unit in a separate panel box, as well as a light source of standard design. A light intensity of 100 foot-candles falling on the cell provides adequate energy for positive operation of the relay system in contrast to the 200 foot-candle level formerly required. Output capacity of the new relay is 500 watts, so that most installations can be handled directly by the relay contacts without the use of external contactors.

The relay is arranged for single-pole, double-throw operation, with an overall speed of response of 0.15 seconds. Positive action of the relay at speeds up to 400 operations per min. permits automatic control of high speed industrial processes for which previous units of this type were unapplicable.

Taylor Valves

TAYLOR MOTOSTEEL diaphragm valve motors, which have been completely redesigned by Taylor Instrument Companies, Rochester, N. Y., are the first to employ an all-steel welded construction. This new construction is lighter in weight, stronger, and has greater resistance to

shock and strains than the cast-iron type.

A smoother, quicker-acting, and more powerful valve motor is obtained by a larger molded diaphragm of advanced design. Formed impressions in the top plate which provide freer access of air pressure to the diaphragm in starting, insure a greater effective initial force, and a longer and larger diameter spring gives greater initial compression, less hysteresis, and more accurate response.

Ball and roller-bearing stem guides, insure a free rolling action throughout the entire stroke. Spring and spring adjusting nut, as well as other moving parts, are fully enclosed, yet are readily accessible for adjustment or maintenance by removing the side plates. Of special importance is the valve position indicator which readily establishes the valve opening.

Goodrich Vulcanizer

FOR VULCANIZING splices in transmission or conveyor belting up to 28 in. wide, the Goodrich No. 28 Aluminum One-Man Vulcanizer has been a recent development by The B. F. Goodrich Co., Akron, Ohio. Through the use of aluminum,

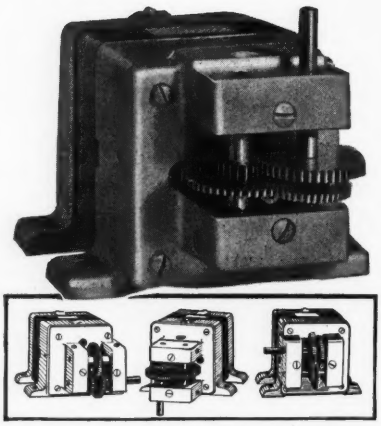
cost of this unit has been greatly reduced and its weight lowered to under 300 lbs.

The Goodrich No. 28 Vulcanizer is suitable for transmission and conveyor belts up to 28 in. and offers the advantage of being able to vulcanize narrow transmission belts up to 10 in., 6-ply inclusive in one heat. The unit is electrically heated by means of 110 or 220 v. current and comes equipped with curing pad and galvanized sheet covers.

Flea Power Motor

THE SPEEDWAY MFG. CO., Cicero, Ill., announce a new "flea power" worm drive, back-geared motor that comes not only in a.c., d.c. and Universal, but at the same time can be assembled with drive shaft to right, to left, up or down. This new feature, it is claimed, greatly simplifies mounting problems and will eliminate the need for complex and angular drives.

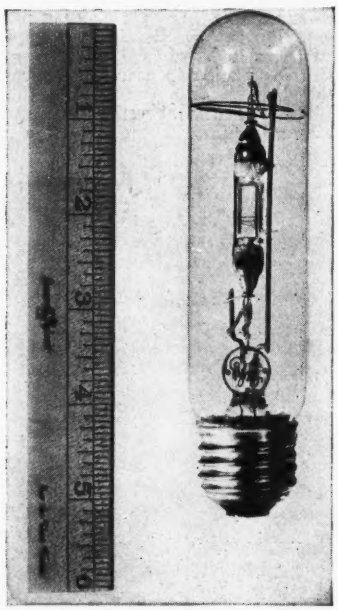
Other features claimed for these small,



back-geared motors include: unusual quietness resulting from an improved worm on the primary reduction and straight, wide faced, cut steel gears on the final reduction; novelty of matched end castings, one of which carries all reduction gears that fit evenly to the motor case; a wide range of selected speeds on the final shaft: 1, 7, 11, 40 or 80 r.p.m. on the a.c. or d.c. unit for instance, as standard speeds, and many others available; extremely small size, 2½ by 3 by 4 in. including the reduction gears; high starting torque; and low inputs from 4 to 15 watts.

New Mercury Vapor Lamp

A NEW 85-WATT MERCURY lamp having a light output of 3,000 lumens and an unusually high unit brightness has been introduced commercially by the General Electric Vapor Lamp Company, Hoboken, N. J. The new lamp represents the latest step in broadening applications for bulb-type mercury lamps, which in the past two years have already achieved wide industrial and commercial use in the 400-watt and 250-watt sizes. Its initial application will be in scientific and industrial uses where its small size and unusual brightness make it particularly desirable.



The lamp is unique in construction and operating characteristics. The actual light source is a minute column of mercury vapor, less than an inch long, raised to an exceptionally high brightness within a sealed quartz tube. The quartz tube is mounted within a Standard T-10 bulb (5½ in. long and 1¼ in. in diameter) equipped with a standard screw base.

The small size and efficiency of the lamp, in comparison to its high light output, appear likely to result in the development of compact new fixtures and reflectors meeting unusual industrial and commercial needs. The restricted area and high unit brightness of the light source also opens up possibilities for the use in projection lamp apparatus and other equipment where light is to be focused or its distribution accurately controlled, such as for beacons and possibly new types of highway lighting.

Light from the new lamp possesses color characteristics generally similar to other mercury lamps. Although there is somewhat more red radiation present, the light is still predominantly "bluish" in color quality. Thus it blends well with light from incandescent lamps, making possible new combination "mercury-incandescent" lighting units of relatively low power consumption which produce a pleasing illumination similar in appearance to natural daylight.

In common with other vapor lamps, the new bulb operates through a ballasting type of transformer on standard alternating current circuits. A special line of compact transformers for use with the lamps has been developed concurrently by the General Electric Vapor Lamp Company.

Centrifugal Pumps

DESIGNED FOR service where small space and low weight are essential, Goulds Pumps, Inc., Seneca Falls, N. Y. Fig. 3620 centrifugal pumps are available in standard and special constructions for the handling of ordinary and corrosive industrial liquids. Fifteen sizes meet all capacity requirements from 5 to 1600 g.p.m. The combining of pump and motor in a single unit

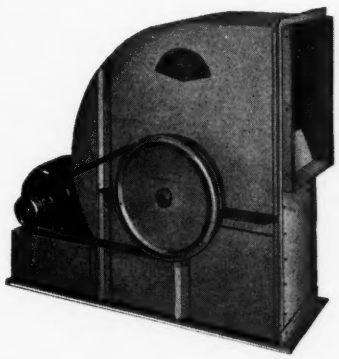
permits marked reductions in overall dimensions and weight without sacrificing strength or durability.

Substantial construction throughout and the mounting of all moving parts on a single oversized shaft, running in heavy duty ball bearings to eliminate friction and wear, assure perfect alignment, eliminate vibration and permit operation of the pump in any position. Impellers, carefully designed for high pumping efficiency, are of the enclosed single suction type with safe motor load characteristics, mechanically and hydraulically balanced, and are securely keyed and locked to the shaft. Casings may be swivelled to any of four positions and are fully equipped with priming, drain opening and air vent cock.

Autovent Blower

AUTOVENT FAN & BLOWER CO., 1805-1827 No. Kostner Ave., Chicago, Ill., has developed The Autovent V Belt Drive Unit Blower to meet a specific need for a combined ventilating unit where, on ac-

count of local conditions, it is not feasible to install a direct connected blower which would require a slow speed motor and which is normally unobtainable from motor manufacturers' stocks. The motor is mounted in the Autovent "V" Belt Drive Unit Blower on a steel pedestal base built integral with the blower housing, making a compact unit, easy to install and insuring flexibility of control.

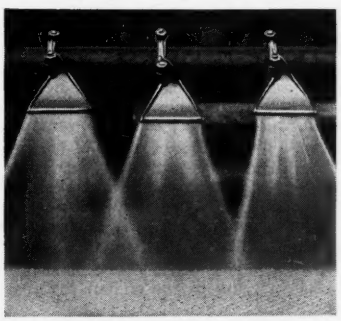


It is made in five sizes, comprising blower wheel diameters from 12½ in. up to and including 25 in. This type of unit eliminates the necessity of making a separate installation of motor base and required centering of the motor for drives, thus providing the contractor with simply a single unit to set in place.

New Spray Nozzle

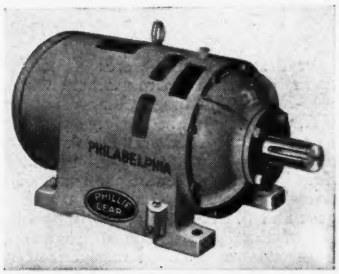
ANNOUNCEMENT IS MADE by Link-Belt Company that it has developed a simple, effective non-clogging spray nozzle for spraying, washing, cleaning all kinds of materials, screens, fruit, vegetables, etc.

It is described as a scientifically shaped, smoothly polished curved bronze deflector with U-bolt for clamping the deflector securely to water pipe, in such a position that it is just above the orifice (a plain drilled hole) in wall of pipe. The width of deflector permits a comparatively large water jet, and thus allows fairly large dirt particles to pass through the orifice without clogging it. To assemble the deflector on pipe, it is only necessary to place it in proper position over the orifice, and then tighten the hex nuts on the U-bolt.



Motor Reducers

TWO NEW SIZES have been added by the Philadelphia Gear Works, Philadelphia, Pa., to the standard series of the totally-enclosed, fan-cooled MotoReduceRs in both the vertical and horizontal types. With several refinements, the new units follow the modern streamline design which enables the unit to blend with, and appear to be a part of, the machine upon which it is installed.

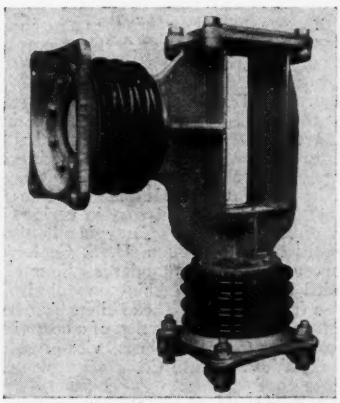


Gear reduction is of the planetary design. All gears and pinions are made of heat-treated nickel steels. All gears and shafts are mounted on anti-friction bearings. Slow speed shafts are mounted on generously spaced, over-size, tapered roller bearings having a high thrust rating. On the vertical types this construction allows vertical shafts, paddles, impellers, etc., to be hung directly from the driving shafts, thereby eliminating the objectionable step bearings.

The lubrication problem has been handled effectively. Horizontal types employ the splash system. The armature extension, carrying the high speed pinion, is equipped with a specially designed, grooved oil slinger which prevents the oil from reaching the windings. Oil level is easily checked by a plug provided for that purpose. The vertical types are equipped with the force-feed system.

Bus Support

THE DELTA-STAR ELECTRIC CO., Chicago, Illinois, have developed a new heavy duty 7500 volt bus support to carry eight 8 by ¼ in. copper bars, constituting the main bus of a large steel mill.



A lower insulator mounts on a steel I-Beam and a side supporting insulator mounts on a concrete wall. These supports are equipped with rollers and spring spacers permitting free lateral movement of the bus.

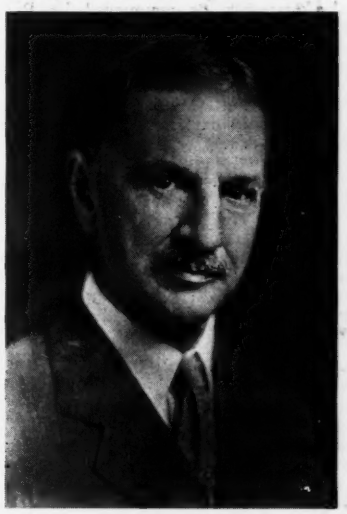
Flux and Solder

THE NEW FLUX developed by the Alumaweld Co. of America, Chicago, Illinois, in conjunction with a special, high tensile strength solder permits high strength, permanent repairs on joints of any metal, with an ordinary soldering iron or blow torch. The soldering is done at low temperature but requires high temperatures to melt it a second time. It works well on aluminum, stainless steel, die-cast pot metal, cast iron, copper, brass, which makes it easy to join any two different metals if desired. Alumaweld Flux works well with any type of solder but, when greater tensile strength is desired, Alumaweld Solder has tensile strength of 12,000 lb. per sq. in. The finished joint can be worked or machined and takes a polish over which chromium or any other plating can be applied.

Brush Service

WITH A VIEW to simplifying the correct selection of replacement brushes for motors and generators in industrial plants, mills, commercial buildings, etc., The Ohio Carbon Company, Lakewood, Ohio, has worked out a "Brush Charting Service" which is available free on request. On analysis of past sales, the Company found that 91 per cent of all replacement orders for "Ohio" carbon, graphite, electro-graphitic and metal-graphite brushes can be covered by about one-quarter of the grades generally considered necessary—the remaining three-quarters being used mainly for special and unusual applications. They, therefore, prepared a set of charts showing the wide range of uses to which these few grades were suited, with the result that an ample stock of emergency replacements can now be carried at a fraction of the former expense.

MORRIS E. LEEDS, president of Leeds & Northrup Co., Philadelphia, Pa. was the recipient this year of the Henry Laurence Gantt Gold Medal awarded annually by the Institute of Management "for distinguished achievement in industrial management as a service to the community." Henry S. Dennison, who received the award in 1932, presented the Medal to Mr. Leeds at a joint dinner of the Institute of Management and the American Management Association held in New York on June 14.



During the same week the honorary degree of Doctor of Engineering conferred upon Mr. Leeds by Polytechnic Institute of Brooklyn. He was educated at Haverford College and at the University of Berlin, gave up teaching to undertake the manufacture of scientific instruments through the company which he founded in 1899.

News From the Field

DANIEL DELANEY, who was 81 yr. old, died of a heart attack July 3, at his home in Evanston, Ohio. He collapsed as he went to a telephone to answer a business call. For 35 yr. he had been Cincinnati Manager of the Dearborn Chemical Co., Chicago, and prior to that he was a power engineer. For 50 yr. he was active in the National Association of Power Engineers, having at one time been treasurer of the organization. He was a former President of a Cincinnati group, which honored him at his last birthday, June 18, by giving him a gold plaque and the title of "President Emeritus." Mr. Delaney was born in Covington, Ky.

HENRY F. BAUER, Chester Twelfth Building, Cleveland, Ohio, has been appointed sales representative for Bernitz Furnace Appliance Co., Boston, Mass.

CONTRACT HAS BEEN awarded by the Great Lakes Steel Corp. to the Semet-Solvay Engineering Corp., of New York, for the building of a pipe line which will convey blast furnace gas from the Hanna furnaces, on Zug Island, to the Delray plant of the Detroit Edison Co. The gas line will be 48 in. in diameter and will be of welded steel construction. The line will start at the Hanna Furnace plant and cross the Rouge River over a new bridge, to be constructed, and which is a part of the undertaking. It will then run some 2400 ft. to the Edison property. The river crossing will be approximately 200 ft. and will clear the high water line by 150 ft. The pipe will be fabricated in the Semet-Solvay Engineering Corp. shops at Owosso, Mich.

WILLIAM E. AUSTIN, manager of Richmond branch, National Radiator Corp., has been elected vice-president and southern sales manager, as announced by R. S. Waters, president. Mr. Austin has been with the organization since June, 1914. He will have charge of sales in Virginia, No. and So. Carolina, Georgia, Florida, Tennesse, Alabama, Mississippi and Louisiana, with headquarters at 3032 Norfolk St., Richmond, Va.

C. O. BARTLETT & SNOW CO., Cleveland, Ohio, announces the appointment of P. K. Reed to its engineering and sales departments. Mr. Reed, who is well known throughout the industry, was for many years chief engineer and later Chicago manager of the R. H. Beaumont Co., and more recently president of the Atlas Conveyor Co.

AT THE SEMI-ANNUAL Meeting of The American Society of Mechanical Engineers, held at Dallas, Texas, June 15-20, 1936, James H. Herron, President, The James H. Herron Co., of Cleveland, Ohio, and at present vice-president of the Society, was nominated President of the Society.

Vice-presidents nominated to serve on the council were James M. Todd, consulting mechanical and electrical engineer, of New Orleans, La., at present a manager of the Society; James A. Hall, professor of mechanical engineering at Brown University, Providence, also a manager of the Society; and R. J. S. Pigott, staff engineer in charge of engineering, Gulf Research and Development Corporation, Pittsburgh, Pa., and chairman of the Society's special research committee on fluid meters.

Nominations for members of the council to serve as managers were: Kenneth H. Condit, editor, American Machinist, McGraw-Hill Publishing Co., New York, N. Y., chairman of the Society's committee on professional divisions; E. W. Burbank, Dallas, district manager, Allis-Chalmers Mfg. Co., Dallas, Texas, chairman of the Society's committee on relations with colleges; and S. W. Dudley, newly appointed dean of the Yale School of Engineering, Strathcona professor of mechanical engineering, Yale University, New Haven, Conn., and chairman of the Society's committee on publications.

At a meeting of the council of the Society held during the Dallas meeting, it was voted to hold the 1937 Semi-Annual Meeting at Detroit, Mich.

AT A RECENT MEETING in New York city the announced plan of the anthracite industry to launch a coöperative program to promote the many advantages of anthracite as a fuel took concrete form. The organizations to conduct the program was completed. A corporation was organized under the name of Anthracite Industries, Inc., to inaugurate a large and comprehensive campaign. It will acquaint the public with the many new and modern developments in the use of anthracite and anthracite burning equipment. The members of the Board of Directors of the new corporation elected as President, Frank W. Earnest, Jr., who comes to his new duties with a wide experience in the fuel market and in marketing anthracite burning equipment gained as Vice President and General Sales Manager of the Spencer Heater Co., Williamsport, Pa.

PROFESSIONAL DEGREE of mechanical engineer was conferred on W. H. Stueve, in charge of oil industry power sales for Oklahoma Gas & Elec. Co., by Ohio State University in recognition of his work during the past 10 yr. in devising and improving the use of electric power in the oil transporting industry.

PANORAMA OF POWER is the name chosen for the exhibit of power developments and resources to be shown at the Third World Power Conference, Washington, D. C. Sept. 7 to 12. It will present the story for the past 50 yr. by models and pictures of great dams and power plants, lighted maps and photographs, and experimental demonstrations. Part of the exhibit will be in the National Museum, part in the Mayflower Hotel, and part in various institutions such as Carnegie Institute, Smithsonian Institution, U. S. Geological Survey, Bureau of Standards. Four electrified farms near Washington will also be open for inspection. The exhibits have been gathered under the direction of a committee headed by C. E. Stephens, vice-president of the Westinghouse Co.

WILLIAM H. PHILLIPS, recently with Harry Pratt Co. of Chicago, has joined the Worthington Pump & Machinery Corp. as power plant specialist with headquarters at the Corporation's Chicago office. Mr. Phillips was formerly for many years with the Worthington Pump & Machinery Corp. He will specialize on condensers, steam-air ejectors, feedwater heaters and boiler feed pumps.

CRANE CO., with offices in Indianapolis, South Bend, Muncie, Terre Haute, Evansville and East Chicago, Ind., have been appointed representatives for the state of Indiana by the American District Steam Co., North Tonawanda, N. Y.

AT THE MEETING of the Smoke Prevention Association held June 2 to 5 in Atlanta, Ga., the following officers were elected: J. C. Bryan, President, Smoke Commissioner, St. Louis, Mo.; W. E. E. Koepler, Vice President, Bluefield, W. Va.; W. C. Shove, Vice President, New York, New Haven and Hartford R. R., New Haven, Conn.; Frank A. Chambers, Secretary-Treasurer, Chief Smoke Inspector, Chicago, Ill. The next convention will be held in New York City sometime next year, announcement of the dates to be made later by the Secretary, Frank A. Chambers.

J. C. BLOOMFIELD is now with the shovel, dragline and crane sales division of Link-Belt Co., specializing on application of this equipment to railroad service. L. P. Spillan has been appointed division sales manager of the shovel and crane division for sales to contractors. N. A. Weston has charge of shovel division industrial sales in the Chicago district. G. H. Olsen remains as general manager of the shovel and crane division.

LOS ANGELES, California, sales office of Cutler-Hammer, Inc., Milwaukee, Wisconsin, has been moved to new quarters at 1331 Santa Fe Avenue, in charge of W. G. Tapping.

THE LINCOLN ELECTRIC CO. announces appointment of Intermountain Belting and Packing Co. at 1414 Wazee St., Denver, Colo., as its agent to cover Colorado and parts of Kansas, Nebraska and Wyoming. Officers of the Intermountain Belting and Packing Co. are J. H. Johnson, president, M. H. Wiekey, vice-president, J. I. Creighton, secretary and treasurer. These men, assisted by Homer Glan and James Kelley, will cover the territory and give consultation service to users of welding, without charge.

GENERAL REFRACTORIES CO., Philadelphia, Pa., has removed its general offices into new quarters in the Real Estate Trust Building at Broad and Chestnut Streets.

HENRY FORD turned a valve control wheel July 15 that put into operation the new 110,000 kw. 1200 lb., 900 deg. F. turbogenerator which, with a 15,000 kw. back pressure unit and a new high-pressure boiler, has been installed at the River Rouge plant of the Ford Motor Co. at a cost of $4,600,000.

Starting of the new unit was witnessed by a number of Ford officials, including Edsel Ford, W. W. Dulmage, chief engineer of the Ford power plants, C. E. Sorensen, P. E. Martin, W. J. Cameron, and A. R. Smith, chief engineer of the General Electric Co., and designer of the unit.

With consumption of electric power by the Rouge plant at an all-time peak, work has been started on additional power-distribution equipment. The structure and equipment will cost approximately $420,000.

Peak demand of the Rouge plant is now 155,000 kw. and by the end of the year is expected to reach 180,000.

EDWIN J. SCHWANHAUSSER, manager of the Buffalo Works of the Worthington Pump and Mach'y. Corp., has been elected president of the Buffalo Chamber of Commerce. Mr. Schwanhausser, a graduate of Stevens Institute of Technology, has been active in association activities for many years and is also chairman of the Executive Committee of the Interallied Foundries of New York State, a member of the State Advisory Council for Vocational and Apprentice training for the Board of Regents and is a member of the American Society of Mechanical Engineers.

For the Engineer's Library

THE NEXT HUNDRED YEARS, by C. C. Furnas, published by Williams & Wilkins Co., Baltimore, Md. Size 5½x8½ in., 448 pages, 1936. Price $3.

In this extremely interesting book, C. C. Furnas, associate professor of mechanical engineering, Yale University, discusses the unfinished business of science in such a way as to take the reader on an exploring tour of thought, leading him directly to the problems which science is facing and pointing to the many advantages which may be obtained by the solution of these problems. The book may be classed as a series of expanded editorials on nearly all phases of science as we know it today. It is divided into five parts dealing with biology, chemistry, physics, engineering and social consequences. Those parts of particular interest to engineers are chemistry, physics and engineering. The latter is treated under the headings of the road ahead, labor saving, power, light, transportation, communication, mineral resources, a perfect farm, agriculture in industry, food manufacture and making the best of weather.

RESEARCHES IN HIGH PRESSURE STEAM at Purdue University, prepared by A. A. Potter, H. L. Solberg and G. A. Hawkins, is published as Research Bulletin No. 52 of the Engineering Experiment Station, Purdue University, Lafayette, Ind. It describes in considerable detail the work on the experimental forced-circulation, once-through, high-pressure steam generator installed in 1931. Outlet pressures up to 3580 lb. have been investigated and the same design could be used for higher pressures by use of heavier tubing.

DIESELS AND OTHER INTERNAL COMBUSTION ENGINES. By Howard E. Degler. Published by American Technical Society, Chicago, Ill. Size 5½ by 8½ in., cloth bound, 237 pp. Price $2.

This is the second edition of a book originally published in 1931. The new edition was made necessary by the rapid progress, increased importance and wider application of Diesel engines. Practically the entire book has been rewritten and new parts, including high speed engines, economics of Diesel power, heat recovery from exhaust gases, have been included. It is a practical text on the development, principle of operation, construction and performance of various types of internal combustion engines and is written in a clear and concise manner, well illustrated.

LOWER-COST Manufacturing by Shielded Arc Welding, a 16-p. booklet issued by The Lincoln Electric Co. of Cleveland, Ohio, discusses the simplification of parts, reduction in costs and ease of manufacture obtained by the use of welding in place of casting or riveting. Numerous examples of parts and machines produced by welding are described and illustrated.

ANACONDA Copper Bus Conductors is the title of a bulletin just released by the Anaconda Wire & Cable Co., New York, N. Y. It contains performance data on various bus arrangements, also a new and interesting illustration of a phenomenon which is explained briefly and concisely.

THE WILL-BURT CO., Orville, Ohio, is distributing a folder dealing with the Will-Burt commercial stokers which are built in the domestic, semi-commercial and commercial sizes and are of the underfeed type with full automatic control.

GEO. D. ROPER CORP., Rockford, Ill., has recently published two interesting bulletins dealing with rotary pumps. Bulletin R-7 describes Roper rotary pumps for industrial plants, bulk stations, refineries, tanker terminal service and general purposes. Bulletin R 511 deals with direct drive rotary pumps for general use.

YARNALL-WARING CO., Chestnut Hill, Philadelphia, Pa., is distributing two bulletins dealing with Yarway impulse traps. Bulletin T-1732 is entitled "What Makes the Yarway Steam Trap Work?" and is a detailed description with colored drawings explaining the principles involved in this unique trap. Bulletin T-1721 gives a general description of the trap together with installation drawings, tables of capacities, prices and dimensions.

IN THE POWER SPECIALIST for May-June, issued by Johns-Manville, New York City, is an interesting article on a New Job for Diatoms showing their effect when used as an ingredient in paint and varnish in increasing durability.

RECORDING THERMOMETERS as made by the Republic Flow Meters Co., Chicago, Ill., with "cartridge sealed" helix, removable for recalibration or repair, are described and illustrated in detail in Data Book No. 210, available on request to the company.

FEATURES and advantages of Radiostat control of heating in accordance with outdoor temperature as furnished by Link-Belt Co., Chicago, Ill., are described and illustrated in Folder No. 1518 on the company's heating system, and No. 1517 on The Miracle of the Radiostat. Saving by avoidance of overheating in office buildings, apartment buildings and public institutions is quoted.

HYDRAULIC TURBINES is the title of Bulletin 100 recently issued by I. P. Morris Division of Baldwin-Southwark Corp., Philadelphia, Pa. This bulletin is devoted almost entirely to photographs of hydraulic turbines taken during the course of construction in the factory, many of which are soon to be installed in plants throughout the country. There is also an extensive list of installations of I. P. Morris turbines included.

ABART SPEED REDUCERS is the subject of Bulletin 1200 recently issued by Abart Gear & Machine Co., 4834 W. 16th St., Chicago, Ill. This bulletin contains dimensional drawings and tables of horsepower capacities of straight line drive spur gear speed reducers manufactured by the company.

D. W. HAERING & CO., INC., 3408 W. Monroe St., Chicago, Ill., has just published a booklet entitled the Art of Proportioning which describes several types of proportioning units required for handling various liquids utilized in the process industries.

UNION RADIANT HEAT BOILERS is the subject of a folder recently issued by the Union Iron Works of Erie, Pa. The folder contains drawings of a number of these boilers installed in plants throughout the country and gives notes on results secured.

THE HOLOPHANE CO., 342 Madison Avenue, New York, announce the publication of a new catalog on lighting facts called "Datalog". . . . This book which is attractively designed contains 44 pages of illustrations and descriptions on the complete Holophane line of newest equipment for scientific lighting. . . . Classification of the contents has been prepared especially to facilitate reference.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., has issued an interesting folder entitled "Coördination With the Greatest of Ease" which deals with the Brown air operated controllers. The folder describes the simplicity of these instruments and indicates a number of the applications in the industrial field.

LOWER PIPING COSTS, a booklet issued by The Lincoln Electric Co., Cleveland, Ohio, illustrates many ways of fabricating piping installations by welding and shows the cost of piping, its erection and finish when shielded arc welding is used.

SULLIVAN MACHINERY CO., Michigan City, Indiana, announces a new air compressor unit designed for truck mounting, of two-stage type and capacity 105 c.f.m., with anti-friction bearings and automatic control, drive to be taken from the truck propeller shaft. It is described in Bulletin A-14.

Also a new stationary heavy-duty air and gas compressor, 1-stage, 1 cylinder, with replaceable cylinder liner, Timken double-row main bearings, in sizes 10 to 50 hp. and for pressures 5 to 150 lb. per sq. in. It is described in Bulletin A-13.

DIESEL ENGINE IN INDUSTRY is an attractive illustrated folder in color, just issued by Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo. Advantages of the Diesel for this service and photographs of representative installations are included.

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., have just issued a number of new folders as follows: Worthington vertical 4-cycle, type AG gas engines; vertical 4-cycle, direct injection type BB Diesel engines; Type VV single and 2-stage vertical vacuum pumps; single and 2-stage types HBV and HSV horizontal dry vacuum pumps; Two-stage types V3, A2, air compressors; high pressure-high temperature centrifugal boiler feed pumps; horizontal duplex pump and receiver sets; Monobloc centrifugal pumps.

TYPICAL air conditioning installations and freon or methyl chloride refrigerating units are described in two bulletins just issued by the Carbondale Machine Corp., Harrison, N. J. These are bulletins 1105A and 1119.

MICROMAX Thermocouple Pyrometers, describing the potentiometer method of measurement as utilized by Leeds & Northrup Co., 4900 Stenton Ave., Philadelphia, Pa., are described in a new 52 page catalog N-33A. The new Silver-Anniversary Micromax recently announced is described in detail.

GENERAL RADIO CO., Cambridge, Mass., has recently issued a new 4 page circular describing Variac Transformers for Voltage Control. The Variac is an auto transformer consisting of a single winding on a turoidally shaped core, the ratio of which can be varied uniformly to provide varying voltages either below or above line voltage. They have many useful applications in all branches of the electrical industry. They range in capacity from 170 va. to 2 kv-a. and in price from $10.00 to $40.00.

Power Plant Construction News

Calif., Sausalito—American Distillery Co., Sausalito, plans installation of electric power equipment in new additions to local plant, comprising several one-story units. Cost close to $100,000.

Conn., New Britain—Landers, Frary & Clark Co., Center Street, plans installation of electric power equipment in new six-story addition to electric cooking and heating appliance manufacturing plant, 60x300 ft. Entire project will cost over $250,000. W. F. Brooks, Lewis and Gold Streets, Hartford, Conn., is architect.

Ga., Atlanta—Municipal Water Department plans development of new source of water supply to provide about 33,000,000 gals. per day, including pumping plans, water storage facilities, pipe lines and other distributing equipment. Entire project will cost about $700,000. Financing will be arranged through Federal aid. Wiedeman & Singleton, Atlanta, are consulting engineers.

Ga., Rome—Tubize Chatillon Corporation plans installation of electric power equipment in connection with expansion at local rayon mill, to increase present capacity over 50 per cent, including new buildings and machinery. Extensions will be made in power station for larger output. Entire project will cost over $2,000,000, and will be carried out during period of next few months. Executive offices are at 2 Park Avenue, New York, N. Y.

Ind., Gary—Carnegie-Illinois Steel Corporation, Carnegie Building, Pittsburgh, Pa., has plans under way for new steam-operated electric generating plant at steel works at Gary, to replace present old station and provide large increased capacity. It will cost close to $5,000,000, with installation to include high-pressure boilers, turbo-generator and auxiliary equipment. United Engineers & Constructors, Inc., 1401 Arch Street, Philadelphia, Pa., is engineer.

Iowa, Boone—Iowa Electric Light & Power Co., Cedar Rapids, Iowa, plans extensions and improvements in steam-operated electric power plant at Boone, including additions to transmission and distributing lines. New franchise is being secured. Entire project will cost over $350,000.

La., Winnfield—Mansfield Hardwood Lumber Co., Shreveport, La., plans installation of electric power equipment in connection with proposed rebuilding of mill at Winnfield, recently destroyed by fire. Loss estimated close to $100,000.

Md., Cumberland—Potomac-Edison Co., East Washington Street, Hagerstown, Md., plans new steam-operated electric generating plant at Amcelle, near Cumberland, with initial capacity of 10,000 kw. Proposed to begin work early in 1937. Company has approved plans for expansion in present power plant at Williamsport, Md., with installation of new boilers and other equipment, estimated to cost over $150,000. Sanderson & Porter, 52 William Street, New York, N. Y., are consulting engineers.

Mich., Bay City—City Council, J. Harry Nelson, city manager, is considering construction of new municipal electric light and power plant, including electrical distributing lines. Cost estimated at $550,000. A special election will be held soon to vote bonds for project. Financing will be carried out through Federal aid.

Mich., Pontiac—General Motors Truck Co., Fisher Body Division, plans installation of electric power equipment in new one-story plant unit at Pontiac, 180x1000 ft. Entire project will cost over $400,000. Main offices of company are at 2935 Vermont Avenue, Detroit, Mich. Albert Kahn, Inc., New Center Building, Detroit, is architect and engineer.

Minn., Duluth—Board of Public Utility Commissioners, City Hall, Ernest A. Bodin, chairman, plans municipal steam power plant for central steam-heating system in East End district. Entire project will cost close to $3,000,000, of which about one-half will be secured through Federal aid and remainder through bond issue. Necessary financing is under consideration. Charles Foster, Medical Arts Building, consulting engineer, has made a survey and report for project.

Minn., Lakefield—Village Council plans extensions and improvements in municipal electric light and power plant, including installation of two new Diesel engine units, about 450 and 280 hp. capacity, respectively, and auxiliary equipment. Cost close to $50,000. Early purchase of equipment is proposed.

Mo., Liberty—City Council plans early construction of a municipal electric light and power plant, and will engage consulting engineer to prepare detailed plans. Cost about $140,000, including distributing lines.

N. C., Shelby—City Council has plans maturing for new municipal electric light and power plant, including electrical distributing lines. Fund of $225,000 is being secured through Federal aid.

Ohio, Cincinnati—Chevrolet Motor Co., Smith Road, Norwood, Cincinnati, plans installation of electric power equipment in new one-story addition to local Fisher Body works, to be used for assembling division. Entire project will cost over $80,000. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer. Company headquarters are at 3044 West Grand Boulevard, Detroit.

Ohio, Cincinnati—Trailer Co. of America, Inc., Thirty-first Street and Robertson Avenue, plans installation of electric power equipment in new three-story addition to automobile trailer works. Entire project will cost about $75,000, and will be placed under way soon. John Henri Deeken, Times-Star Building, Cincinnati, is architect.

Ohio, Cleveland—Cleveland Twist Drill Co., 1242 East Forty-ninth Street, plans installation of electric power equipment in new five-story factory addition on adjoining site. Bids will be asked soon on general contract. Entire project will cost close to $500,000. George S. Rider Co., Marshall Building, is architect and engineer.

Ohio, Dayton—Inland Mfg. Co., 2727 Inland Avenue, manufacturer of automotive equipment, a division of General Motors Corporation, Detroit, Mich., plans installation of electric power equipment in new plant addition to total about 175,000 sq. ft. floor space. Entire project will cost over $300,000. Work will begin soon. Hillsmith & Co., 108 East Third Street, are engineers.

Okla., Talihina—Purchasing Officer, Department of Interior, Washington, D. C., is asking bids on general contract until Aug. 21 for new hospital building at Talihina, to include a high-pressure steam-generating station, refrigerating plant and other utilities (Proposal 1613).

Pa., Philadelphia—Board of Public Education, Administration Building, Parkway and Twenty-first Streets, plans steam-operated electric power plant in new vocational training school at Mifflin and Eighth Streets. Cost estimated close to $85,000.

Texas, Houston—Municipal Water Department, City Hall, G. L. Fugate, director, is considering extensions in municipal waterworks to develop additional source of supply of about 10,000,000-gal. per day, including several motor-driven pumping plants, storage plants of 2,000,000-gal. capacity each, pipe lines and other facilities. Entire project will cost about $935,000. Part of financing will be arranged through Federal aid.

Texas, Houston—Rheem Mfg. Co., Richmond, Calif., plans installation of electric power equipment in new branch plant on Lockwood Street, Houston, for manufacture of steel barrels, drums, etc. Work scheduled to begin soon. Entire project will cost about $100,000.

Va., Danville—City Council is considering extensions and improvements in municipal steam-operated electric power plant, with installation of new equipment. Cost about $100,000. Station will be used for standby service following completion of proposed municipal hydroelectric power plant on Dan River, estimated to cost $2,750,000, with transmission lines. Financing for latter project has been arranged through Federal aid.

Va., Norfolk—Prest-O-Lite Co., Inc., 30 East Forty-second Street, New York, N. Y., manufacturer of steel gas cylinders for compressed gases, etc., a subsidiary of Union Carbide & Carbon Corporation, same address, plans installation of electric power equipment in new branch plant at Norfolk, where 5-acre tract of land has been acquired. Entire project will cost about $200,000.

Wash., Seattle—Board of Trustees, Swedish Hospital, has plans under way for power plant at proposed new institutional buildings on site recently acquired at Minor Avenue and Marion Street. Bids for power station will be asked soon. It will cost about $50,000. Lincoln Bouillon, Fourth Avenue Building, is engineer.

W. Va., Wheeling—Wheeling Mold & Foundry Co., plans installation of electric power equipment in connection with extensions and improvements in plant for increased output. Entire project will cost about $100,000. Company is a subsidiary of the Continental Roll & Steel Foundry Co., East Chicago, Ind.

Wis., Milwaukee—Pittsburgh Plate Glass Co., Paint Division, 235 East Pittsburgh Avenue, plans installation of electric power equipment in new four-story factory addition. Cost over $150,000. Eschweiler & Eschweiler, 720 East Mason Street, Milwaukee, are architects. Main offices of company are in Grant Building, Pittsburgh, Pa.

Wis., Milwaukee—Schlitz Brewing Co., West Galena Street, plans installation of power equipment, mechanical-handling equipment and other machinery in new four-story addition, to be used as a malt house. Entire project will cost about $350,000. Lawrence E. Peterson, 312 East Wisconsin Avenue, is engineer.